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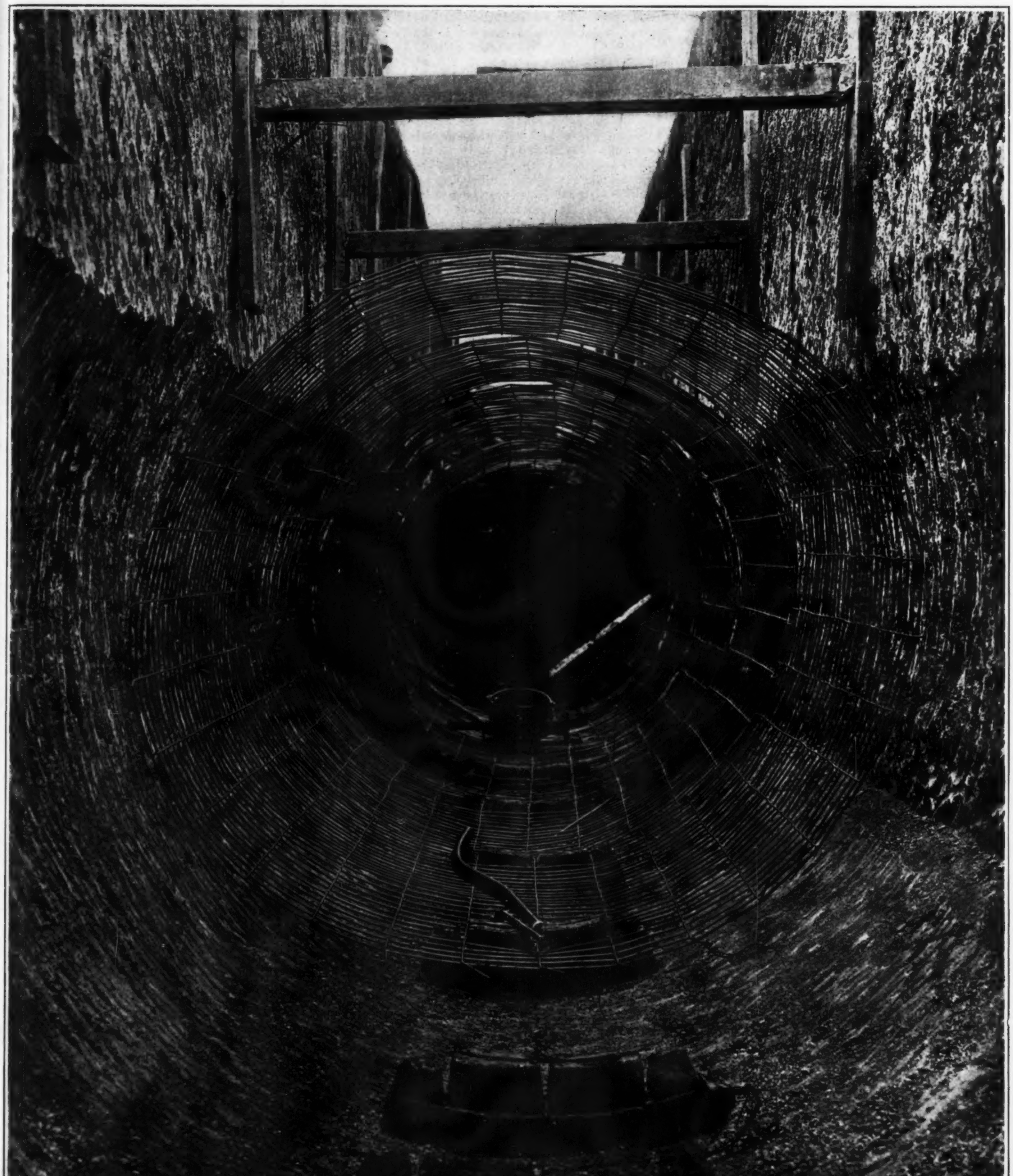


**Building a big outfall sewer at San Antonio, Texas, of reinforced concrete.**

**MODERN CONCRETE STRUCTURES.—****[See page 165.]**

# The Structure of the Earth—I*

## And Some of the Forces That Have Shaped Its Surface

By Prof. Grenville A. J. Cole, F.G.S., M.R.I.A.

The geologist has long been accustomed to regard the crust beneath his feet as subject to changes which are immeasurably slow in comparison with the duration of his personal life. James Hutton has sometimes been charged with catastrophic tendencies, in requiring a complete wearing away of the continents, followed by a somewhat sudden restoration of the land-surface. But he was careful to urge[1] that "the powers of nature are not to be employed in order to destroy the very object of those powers; we are not to make nature act in violation to that order which we actually observe." He remarks[2] that "this world is thus destroyed in one part, but it is renewed in another; and the operations by which this world is thus constantly renewed are as evident to the scientific eye as are those in which it is necessarily destroyed." Yet the operations that are to "give birth to future continents," as well as those that wear down a continent to the level of the sea, are not the result of "any violent exertion of power, such as is required in order to produce a great event in little time; in nature we find no deficiency in respect of time, nor any limitation with regard to power." Far from believing in the complete loss of the former land-surface before upheaval raised the new, Hutton points out that "the just view is this, that when the former land of the globe had been complete, so as to begin to waste and be impaired by the encroachment of the sea, the present land began to appear above the surface of the ocean. In this manner we suppose a due proportion to be always preserved of land and water upon the surface of the globe, for the purpose of a habitable world, such as this which we possess."

### CHANGES IN RELATIVE PROPORTIONS OF SEA AND LAND.

Few geologists, however, will now urge with Hutton that a "due proportion" has always been preserved between land and water on the surface of the globe, if by those words is meant a proportion such as we now enjoy. If we go back to early times, we must consider, with R. A. Daly,[3] the possible grouping of the land against which the Huronian or late pre-Cambrian sediments were formed. Daly has imagined, as one of the causes contributing to a "limeless ocean," a primitive distribution of land and water very different from that which determines our continental land to-day. His pre-Huronian land-surface is pictured as merely a number of large islands, on which no long and conspicuous rivers could arise.

It may be said that this primitive condition of the distribution of land and water is very unlikely to return. But we have evidence that Hutton's "due proportion" has been interfered with from time to time. The very general spread of the sea over the land-margins in Cenomanian times is attributable to a shallowing of the ocean-floors, and it is difficult to say whether this process has been rhythmic or exceptional in the history of the globe. The Carboniferous period opened with marine conditions over a large part of the northern hemisphere, indicating not only a continuation of the Devonian seas, but an overflowing of much of the Caledonian land. The same period closes with an extension of the continental edges, and the formation of swampy flats, in which the vegetation of the epoch has been abundantly preserved. Similarly, the sea which deposited the Cretaceous strata, after encroaching alike on South Africa and Scandinavia, withdrew to a considerable extent in Eocene times.

### THE FOUNDATIONS OF THE EARTH'S CRUST.

Hutton remains at present unassailable in one of his most remarkable propositions. For him, the oldest rocks that we know are sedimentary, and these sediments differed in no respect from those of modern days. This conclusion has, perhaps, not received the full attention it deserves. It now appears certain that we possess no record of a sedimentary type peculiar to the early stages in the formation of a habitable crust. If such a type existed, it has been lost to us through subsequent metamorphism, amounting to the actual fusion and redistribution of its constituents. The Grenville Series of North America rests on a floor of granitoid rock, which is intrusive in it, and which belongs to the oldest of various irruptive groups. The Grenville Series includes conglomerates, false-bedded quartzites, and a development of limestone that is altogether exceptional for pre-Cambrian times. In Finland,[4] sediments have been traced down to the layer where their original characters vanish in a general "magmatitic" ground. Conglomerates and phyllites occur among them, and near Tampere (Tammerfors) the seasonal stratification is as well recorded in a Bottnian shale as it is in the Pleistocene clays made famous in Sweden by De Geer. Vein-gneiss (Adergneis) underlies these ancient systems, and represents their destruction by the injection of granite from below. If we accept the hypothesis of Chamberlin, Hutton's position becomes strengthened by the postulation of an unfused planetesimal crust, and the restriction of molten masses and hydrothermal activity to the interior of a consolidating globe.

So far as we have any record left to us, Hutton remains fundamentally in the right. All modern research shows that the schists and gneisses can be explained by causes now in action. The vast majority of schists were at one time normal sediments; others were tuffs or lavas; but, whether originally sedimentary or igneous, they owe their present characters to widely spread regional metamorphism.

### THE UNDERMINING AND WEAKENING OF THE FOUNDATIONS OF THE CRUST.

Is there, then, any reason to depart from Hutton's position as to the recurring cycle of events in the history of continental land? I think it must be admitted that the isostatic balance was far more frequently disturbed in what we may call Lower pre-Cambrian times than it has been in more recent periods. Local fusion must be regarded as an important cause of crustal weakening. If we wish to study the nature of the process, it is reasonable to examine regions that have at one time lain deep within the crust. Such regions are provided by the broad surfaces of Archæan rocks that were worn down through continental decay before they sank beneath the Cambrian Sea.

It is well recognized that an ancient continent at one time stretched across the northern hemisphere. Wherever later deposits have been stripped from its surface, from Central Canada to the Urals, and probably far beyond, we find that the older materials of this undulating continental platform consist largely of intrusive igneous rocks. These, moreover, have frequently a gneissic structure. Again and again strongly banded gneisses occur in which granitic material, verging on aplite, alternates with sheets of hornblendic or biotitic schist. The biotitic varieties can often be traced back into amphibolites. In places, lumps of these amphibolites are seen, streaked out at their margins, and providing a clear explanation of the dark bands throughout the gneiss.[5] This swallowing up of a mantle of basic material by a very different and highly siliceous magma rising from below is indeed seen to be a world-wide feature, wherever we find the lower crust-layers brought up within reach of observation. The tuffs and lavas of the Keewatin series have supplied the dark material in Canada, and similar rocks have been worked up into the gneisses of Galway, Stockholm, and Helsinki. The frequency of amphibolite in these ancient composite rocks is explained by the fact that this type of rock is the final term of various metamorphic series. While many lumps, for instance, in the gneisses of Donegal are residues of Dalriadian dolerites (epidiorites), others, rich in garnet and green pyroxene, and often containing quartz, are derived from a mixture of sediments in which limestone has been prevalent.[6] During the absorption and disappearance of these masses in the invading granite magma, the amphibole acquires potassium and breaks down into biotite, and biotite-gneisses result, which may extend over hundreds of square miles.

The details of such an igneous invasion are worthy of careful study, since only in this way can we follow out the progress of subcrustal fusion. We see the highly metamorphosed material further attacked by the great caldrons under it, and becoming seamed with intersecting veins. Block after block has been caught, as it were, in the act of foundering into the depths. In the gradual absorption of these blocks, and their penetration by insidious streaks of granite, we see pictured on a few square yards of surface the destruction of a continental floor.

The invasion of a "hard and brittle"[7] crust by an attacking magma was finely described by Lawson in 1888. Lawson pointed out that the Laurentian gneisses gave no evidence of having "yielded to pressures and earth-stresses." The folding of the overlying series was prior to the solidification of the gneisses, and occurred[8] "while the latter were yet in the form of probably a thick, viscid magma upon which floated the slowly shrinking and crumpling strata of the Coutchiching and Keewatin series. . . . Large portions of these rocks have very probably been absorbed by fusion with the magma, for the Laurentian rocks appear to have resulted from the fusion not simply of the floor upon which the Coutchiching and Keewatin rock first rested, whatever such floor may have been, but, also, with it, of portions of those series."

The conversion of the lowest Archæan series, the Coutchiching sediments, into crystalline schists is attributed to thermal metamorphism, and to hot vapors streaming from the molten floor. Lawson realized the importance of shattering in allowing a magma to advance into an overlying "brittle" series, and he is, so far as I know, the first observer to develop in satisfying detail what is now known as the stoping theory of igneous intrusion.

James Hutton always had in mind the effect of heat in "softening" lower layers of the crust. His consolidation of strata by heat is preceded by a stage of melting. Sederholm,[9] while referring back to Hutton as the pioneer, shows how in the vein-gneiss stage the unmelted sediments exhibit plasticity and become intensely contorted. The softening, in fact, induces flow. There is here no crushing or mylonitization, but rather a viscid running of constituents, some on the verge of fusion, some, I venture to think, actually fused. Such rapidly repeated and intricate folding is most intense when *lit par lit* injection has set in, and when the whole composite mass has become weak and plastic. The presence of confined water in aiding this plasticity must on no account be overlooked.

It may be well to illustrate this contention by one or two concrete instances from districts not remote from us at the present time. The noble cliffs of Minaun in Achill Island have been worn by the Atlantic from a mass of evenly-bedded quartzites of Dalriadian age. These are invaded by veins of a very coarse red granite, the main mass of which lies below the present sea-level.[10] The edges of the strata appear fairly horizontal on the cliff-face; but contortion sets in toward the base, and the hard resisting rock has here[11] "undergone intense crumpling and overfolding, such as one meets with on a large scale in mountain ranges, and this contorted flow seems entirely due to the yielding that has taken place in the region of heating." The large size of the constituent crystals of the granite indicates that the surrounding rock was still maintained at a high temperature.

South of Foxford, again, in the county of Mayo, the granite of Slieve Gamph invades a series of micaschists and quartzites. The margin is cut, as usual, by veins that filled the cracks both of the main granite and the metamorphosed sediments. These sediments have become, prior to the shattering, crumpled and overfolded along the contact-region, and the section upon the glaciated slope resembles that of a fluidal rhyolite on a highly magnified scale.

The wonderful contortion of the composite mass that forms the north end of the Ox Mountains (Slieve Gamph) in the county of Leitrim gives a similar impression of

* Presidential address before the Geological Section of the British Association. Abridged by the author in *Nature*.

[1] "Theory of the Earth" (1795), vol. ii., p. 547.

[2] *Ibid.*, p. 562.

[3] "The Limeless Ocean of Pre-Cambrian Time," *Amer. Journ Sci.*, vol. xxiii. (1907), p. 113; and more fully in "First Calcareous Fossils," *Bull. Geol. Soc. America*, vol. xx. (1909), p. 157.

[4] J. J. Sederholm, "Ueber eine archäische Sedimentformation im südwestlichen-Finland," *Bull. Comm. géol. Finlande*, No. 6 (1899), p. 215.

[5] Since the historic works of A. C. Lawson (for example, "Report on Rainy Lake Region," *Geol. Surv. Canada*, Ann. Report for 1887, plates v. and vi ), these features have been traced in many areas. Compare W. H. Collins, "Country between Lake Nipigon and Clay Lake, Ontario," *Geol. Surv. Canada*, Publication 1050 (1909), p. 52; A. L. Hall, Presidential Address on the Bushveld Complex, *Proc. Geol. Soc., S. Africa*, 1914, xxii; P. A. Wagner on Rhodesian gneisses, *Trans. ibid.*, vol. xvii., 39; and works cited in the next reference.

[6] See Michel Lévy, "Granite de Flamanville," *Bull. carte géol. France*, vol. v (1893), p. 337; G. A. J. Cole, "Metamorphic Rocks in E. Tyrone and S. Donegal," *Trans. R. Irish Acad.*, vol. xxxi. (1900), p. 460; O. Trüstedt, "Die Erzlagerstätten von Pitkäranta," *Bull. Comm. géol. Finlande*, No. 19 (1907), pp. 72 and 92; F. D. Adams and A. E. Barlow, *op. cit.* (1910), pp. 25 and 97; F. Kretschmer, "Kalksilikatfelse in der Umgebung von Mährisch-Schönberg," *Jahrb. k k. geol. Reichsanstalt*, vol. lviii. (1908), p. 568, etc.

[7] A. C. Lawson, *op. cit.*, p. 140. See also his revision of the area, *Geol. Surv. Canada*, Memoir 40 (1913).

[8] *Op. cit.*, on Rainy Lake, p. 131.

[9] "Ueber eine archäische Sedimentformation im südwestlichen Finland," *Bull. Comm. géol. Finlande*, No. 6 (1899), p. 133; and "Ueber ptygmatische Faltungen," *Neues Jahrb. für Min.*, Beilage Band 36 (1913), p. 491.

[10] *Proc. Geol. Assoc.*, vol. xxiv. (1913), Plate 17.

[11] G. A. J. Cole, "Illustrations of Composite Gneisses and Amphibolites in N. W. Ireland," *C. R. Congrès geol. internat.*, Canada (1913), p. 312.

viscid flow. The melting of a single constituent of the invaded schists, which here include amphibolites, would enable them to yield in response to the pressures that were forcing the granite magma in thin sheets between them. Their metamorphism is thermal, and the forces that have produced the crumplings are not those of shearing acting on a solid mass, but may have operated from a distance hydrostatically through the magma.

Again, where limestones occur near granite contacts amid a series of various sedimentary types, they display folded structures in an altogether exceptional degree. Silicates have developed along their bedding-planes, but these have become contorted, and rolled upon one another as metamorphism reached its maximum stage. At Maam Cross and Oughterard, in the county of Galway, along the margin of the great granite mass that stretches thence southward to the sea, these flow-structures are conspicuous on weathered surfaces.

The main object of the foregoing discussion is to point out that the Huttonian cycle, in which thermal changes play so large a part, implies a serious weakening of the crust as magmas advance into it from below. The extensive metamorphism of the pre-Cambrian strata, which amounts to a distinctive feature, must, I think, be attributed, not to special intensity of tangential pressures in early times, but to frequency of igneous attack. Much of the crumpling of our schi ts may result from Hutton's "softening," the pressure being supplied from superincumbent masses, or even hydrostatically, and the flow occurring laterally, or vertically downward, toward regions where destruction by absorption was going on. The features seen during the falling in of the walls of the lava-lake of Kilauea in Hawaii afford some idea of what takes place in zones of melting within the crust.

Under such conditions in early pre-Cambrian times, even the surface-rocks must have fallen in at some points and have been replaced by igneous extrusions. Isostatic adjustments must have been very frequently disturbed. Folding of rocks, as a phenomenon of lateral surge and flow, must have made itself freely felt at the earth's surface. It is safe to assert that such conditions have not been repeated on a broad scale at any geological period subsequent to the spread of the Olenellus-fauna. Geochemical evolution, however, may have surprises still in store, and, in spite of long tradition, we are disinclined now-a-days to rely too strongly on arguments based upon the sanctity of human life.

## POSSIBLE BREAKS IN THE SLOW CONTINUITY OF EARTH-MOVEMENT.

### *1. The Mountain-building Stage.*

Even with the thickened sedimentary crust beneath us, and the confidence inspired by our limited experience of the earth, we may ask if subterranean changes may not still result in catastrophes at the surface.

What, in fact, is likely to occur if a mountain-building episode again sets in? Such episodes, affecting very wide areas, have undoubtedly recurred in the earth's history. We do not know if they are rhythmic; we do not know if they represent a pulsation, decreasing in intensity, inherited from the stars and hampered by increasing friction; we do not know if they record internal chemical changes, which have no climax, because they are neither cyclic nor involutionary, but evolutionary. The mid-Huronian chains, now worn down and supplying such valuable horizontal sections, were evidently of great extent; but we cannot say that they were vaster than those of later times.

The phenomena accompanying the growth of a single chain in the Cainozoic era give us, at any rate, ample food for thought. Though the narrow cross-section of the core of such a chain limits our field of observation, the same impressings of igneous material, and the same features of rock-weakening and rock-destruction, may be observed as in the immense basal sections exposed in the Archæan platforms. The progress of geological time has not diminished the activity in the depths. The granodiorite of western Montana,[12] for instance, which intruded during an uplift in early Eocene times, has attacked the Algonkian sediments of the district, producing phenomena of stop'ng and assimilation in the true "Laurentian" style.

In the western and central Alps, again, the absence of any fossiliferous strata older than the Carboniferous arouses some surprise, until we find that many of the granitic intrusions are of late Carboniferous age. The crystalline schists west of Caslav in Bohemia and in the Eisengebirge are now attributed by Hinterlechner and von John[13] to the metamorphism of Ordovician strata by younger granite, which intruded in post-Devonian and probably in Carboniferous times. Much of the gneiss and granite of the Black Forest and the Vosges is now, moreover, removed from the Archæan, and is shown to be associated with the Armorican movements.[14] These vast intrusive masses occupy the place of strata of pre-Permian age. The great development of thermal metamorphism in the Erzgebirge and in Saxony,[15] two classic regions of the dynamo-metamorphic school, is now widely recognized, and this activity is also assigned to late Carboniferous times. The work of C. Barrois in Brittany is concerned with absorption-phenomena resulting from intrusions during the same mountain-building epoch.

Sederholm[16] has suggested that the ground above an area affected by processes of mountain-building cracks and becomes faulted, while the more plastic zone below flows under pressure into folds. But the blocks of the "brittle" layer, as Lawson has it, may be seriously displaced by movements in the zone of folding, and subsidences of a regional character may occur. The pressure that ha driven an excess of matter to the region of overfolding has squeezed it from beneath an adjacent region. Crumpling and overfolding are accompanied by a shearing away of the matter in one zone from that of another which overlies it; this must result in considerable disturbance of the zone nearer the surface.

We usually regard such disturbances from the uniformitarian point of view. May not, however, actual mountain-building be the break in a slow process of "softening," to use Hutton's term? For a long time the isostatic balance suffers only small disturbances, restoring itself automatically on a gently yielding underworld. Then something gives way; something—a large mass of supporting rock—suffers a change of state. The balance is destroyed abruptly, and mountain-building and rapid subsidences have their day. O. Ampferer,[17] with his customary largeness of view, has referred superficial evidences of disturbance, such as mountain-ranges, to dragging movements of a mobile *Untergrund.* He urges that physical and chemical changes within the earth may produce considerable local changes of volume. Vertical movements lead to upfolding, and this leads to gravitational sliding. The zone of folding that we have been considering as normal near the *Untergrund* thus becomes transferred to the surface of the earth.

I am not now concerned with the causes of folding, beyond the fact that at a certain critical stage the material involved may move at a rapid rate. Changes of state, physical and chemical, occur with some abruptness. In the case of rocks, the softening or melting of even one constituent may allow of flow, and, as we have observed, this flow in a lower layer may soon become manifested in surface-changes.

Ampferer and Hammer[18] have recently considered the overfolded structure of mountains as due to a considerable local reduction in volume of the *Untergrund.* The upper crust presses inward from opposite sides, and the parts that are thrust downward become absorbed and carried away with the retreating region of the *Untergrund.* The surviving parts fall over on either side, producing, as the whole continues to close in, folds that are not so very different from the now familiar *nappes de recouvrement* which these authors hesitate to accept. The important point for our purpose is the restatement of the results of gravitation on the flanks of an uprising chain.

The surprising thing about our folded mountain-chains is the way in which they have been eroded parallel to the strike of the overthrust sheets or overfolds. Apart from occasional detached "klips," the distal parts of these masses must have been at one time continuous with those proximal to the root-region. The forward movement could not have occurred if denudation had negatived the effects of folding on the surface.

The marine or lacustrine deposits of the age immediately preceding that of uplift obviously cannot be consolidated at the epoch of upheaval. Gotlandian sands and muds must have overlain the heaving masses that rose as Caledonian land. The swamps of the Coal Measures were contorted in the Armorican chains; the highest beds of these must have been as yielding and as capable of flow as the Flysch that overlay the growing Alps. In all these cases, familiar to us in Europe, the covering masses must have responded to the crumpling under them, and, when reared to dangerous eminences, rapidly became a prey to denudation and gravitational downsliding. They can scarcely be regarded as protective, and their removal would leave the brittle masses below more liable to fracture and to the "calving" process that forms klips.

In some cases separation seems to have taken place as the moving mass fell forward. The klips of hard material embedded in softer strata are thus a kind of rock-spray, hurled in advance of the breaking earth-wave.

Termier[19] in no wise fears to speak of the progress of a "traineur écraseur" during mountain-building as "soudain et rapide comme une rupture d'equilibre, le dernier acte, longuement péparé, mais joué *d'emportement*, de ce drame grandiose."

Rupture combined with rapid movement of the rocks need not be the last act of the dramma; but, the more we examine the history of folded chains, the more probable it appears as a culminating episode. The original cover of our present ranges has been lost by denudation. Earth-sculpture in these regions of high altitude and vehement attack has removed much of the evidence that we seek. What remains, however, may lead us to feel that no part of the world in historic times has experienced a mountain-building episode.

Such relatively catastrophic stages have, indeed, not been common in the long history of the earth since pre-Cambrian times. It appears that now and again the "orogenic collapse" of some considerable area disturbs the balance in the crust and spreads far through the upper layers like a disease. Or it may be that the thermal cause of the collapse is common to the whole earth at the same time, and becomes manifest in responsive regions far apart. In any case, the weak places give way and the more resisting ones close in. A readjustment is effected, which then endures through long geological time.

The imminent menace of crustal changes was brought home to us during the terrible period from April 4, 1905, to January 14, 1907, the final twelve months being marked by a veritable earth-storm. Geologically speaking, however, we are near enough to the Tortonian epoch to look forward with some confidence to a quiescent phase. But some day, in its due season, the earth will once more be active. When that time comes, no ingenuity of man will suffice to meet it. Earthquake after earthquake, increasing in intensity, will probably have driven the population to a distance from the threatened zone. Concentration of the folding along a particular earth-line will limit the region of absolute destruction; but the undulations spreading from it, in response to the heavings of the chain, will offer sufficient chances of catastrophe. In the case of our youngest mountain-ranges, these undulations remain perpetuated as domes and dimplings of the crust, which are already worn down or infilled respectively by denudation and deposition. Their present forms and places record the last movements of the earth-storm, just as a buckled tramway-rail records the passage of an earthquake. How shall we gage to-day the intensity of their rise and fall?

In the case of the city devastated by an earthquake, the débris is cleared away, and our descendants in time discover the distorted rails beneath the healing mantle of new grass. Will they realize from this alone the preliminary tremors, the sudden arrival of the culminating vibration, the shock that overcame the elasticity of the crust beneath them, and then the gradual establishment of the conditions under which they have passed their peaceful lives? The crumpled wreckage lies there in evidence before them; but how will they distinguish the work of a few stormy seconds from that due to the gentle earth-creep of a century?

### . *Regions of Subsidence.*

It was probably E. Suess who brought home to most of us the importance of regions of subsidence in defining the lowlands and the sea-basins from the upstanding masses of the crust. While one region may be folded, another may be broken into blocks; and the two types of movement, that due to tangential thrusting and that due to vertical uplift and down-faulting, may appear in the same region and may alike play their part in producing a lowering of large areas. The domes and dimples that occur beyond the region of acute crumpling may be intensified into fault-blocks by fracture of their boundaries. If catastrophes are possible during uplift, we may look for them also during subsidence.

The cutting-up of mountain-chains by transverse fractures has resulted in the loss of huge blocks beneath the sea. In such cases it is clear that faulting has run a long way ahead of denudation. All trough-valleys, which are often called, somewhat misleadingly, rift-valleys, raise the same questions as to the nature of the steps by which they have been produced. The Rhine Vale, one of the most closely studied examples, dropped 8,000 feet within the limits of Oligocene time. It is improbable that the numerous faults now traceable operated with concerted gentleness.

*(To be concluded.)*

**An Anemometric Paradox.**—A correspondent informs us that about eight years ago he saw in New York a water wheel constructed on exactly the same principles as the wind wheel described under the above head in the issue of the SUPPLEMENT of February 12th. The model exhibited was intended for use in rough and tidal waters.

[12] J. Barrell, "Marysville district, Montana: a study of igneous intrusion and contact metamorphism." *U. S. Geol. Survey*, Prof. Paper 57 (1907), and W. H. Emmons and F. C. Calkins, "Phillipsburg Quadrangle," *ibid.*, Paper 78 (1913).

[13] *Verhandl. k. k. Reichsanstalt*, 1910, p. 337, and *Jahrb.*, *ibid.*; vol. lix. (1909), p. 127.

[14] P. Kessler, "Die Entstehung von Schwarzwald und Vogesen," *Jahresberichte Oberrhein, geol. Vereines*, vol. iv. (1914), p. 31.

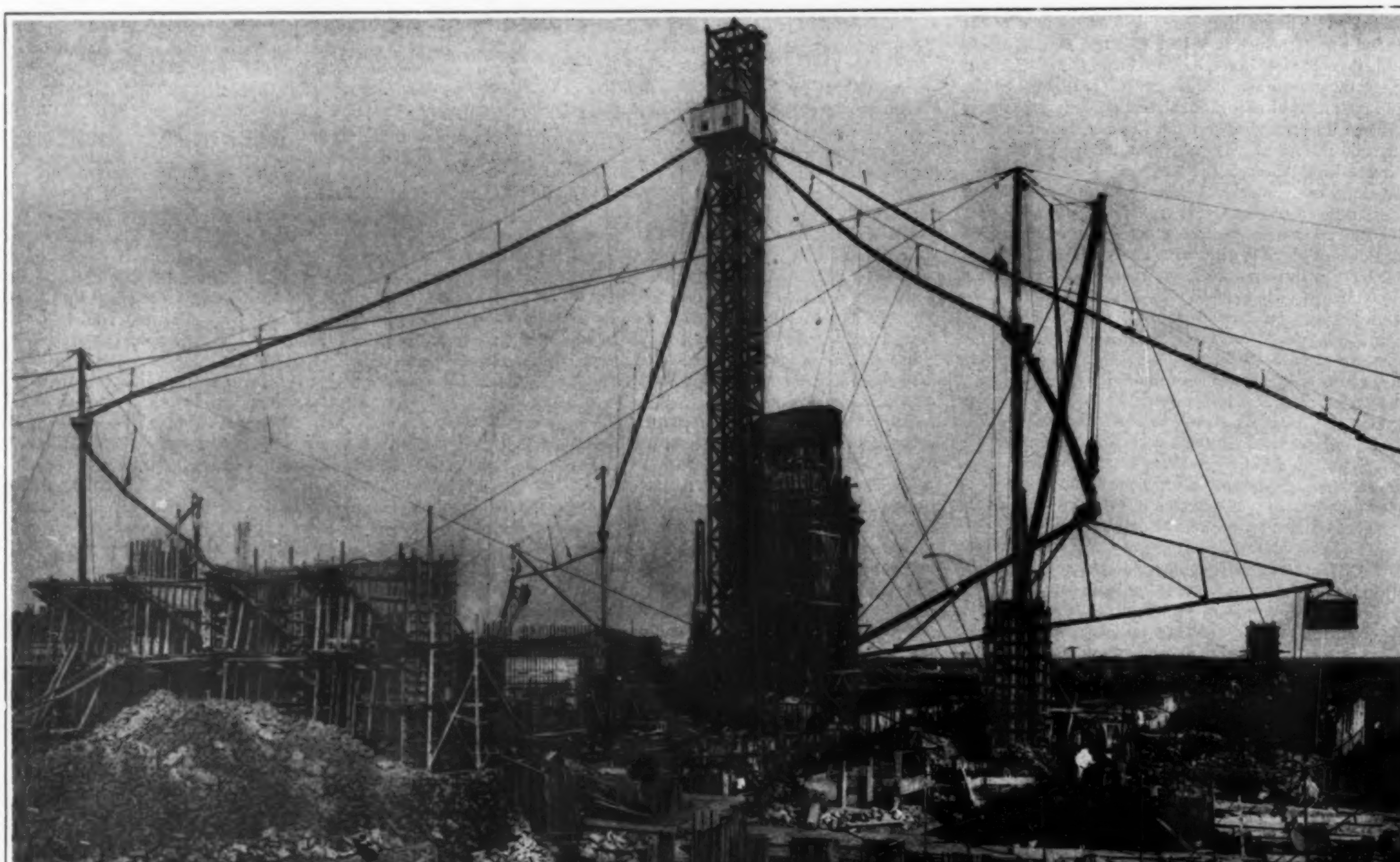
[15] C. Gäbert, *Zeitschr. deutsch. geol. Gesell.*, vol. lix. (1907), p. 308; R. Lepsius, "Geologie von Deutschland" (1910), pt. 2, pp. 107 and 172.

[16] *Op. cit.*, *Bull. Comm. géol. Finlande*, No. 37, p. 66.

[17] "Das Bewegungsbild der Faltengebirgen," *Jahrb. k. k. geol. Reichsanstalt*, vol. lvi. (1906), p. 607.

[18] O. Ampferer and W. Hammer, "Geologischer Querschnitt durch die Ostalpen," *Jahrb. k. k. Reichstanstalt*, vol. lxi. (1911), p. 700.

[19] "Les Problèmes de la Géologie tectonique dans le Méditerranée occidentale," *Revue générale des Sciences*, March 30, 1911.



Laying the concrete foundations for the new Field Museum in Chicago.

# Handling Concrete in Building Operations

## Apparatus Designed for Rapid and Economical Operation

Many large structures are now being built entirely of concrete, or their foundations are composed of this useful material, necessitating the mixing and placing of very large amounts of material. In the earlier days of concrete construction the mixing of the concrete was done, a little at a time, close by the place where it was to be deposited, but this method of procedure was soon found to be expensive, owing to the large amount of handling, both of the materials and of the concrete after mixing; and it was also slow because either small hand mixing platforms were employed, or small mechanical mixers which had to be transported from place to place, and as structures increased in size much ingenuity has been exercised in devising plans whereby the large quantities can not only be rapidly mixed but economically placed.

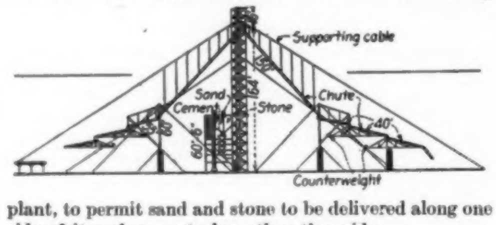
An example of the problems that confront the modern builder is the new Field Museum of Natural History, which is now under construction in Chicago. This building, which is located in Grant Park, is to be 706 feet long and 438 feet deep, and is to be of white Georgia marble. The central section contains a lofty entrance hall, while the main display spaces are located in two symmetrical wings that flank the central portion. These wings are divided into a series of bays, the outside bays and each alternate one being three stories high, while the intermediate bays are only one story, and are provided with skylight roofs, the arrangement insuring ample light for the displays.

The foundations of this great structure are of reinforced concrete, and the problem that confronted the builders was to rapidly mix and place a very large quantity of material distributed over the great area covered by the building operations; and this they did by an ingenious elaboration of methods that have been in the course of development for several years. The site of the museum was once a part of Lake Michigan, and was covered by water to a depth of about 15 feet, but it had been filled in a number of years ago.

The foundations include concrete piers placed on clusters of wood piles, the pier bases being about 2 feet 6 inches below the lake level. The basement floor is at elevation 34 feet and the first floor at elevation 50 feet, or 50 feet above the lake level.

These piles are of Georgia pine, 60 feet long, 9 inches diameter at the tip, and from 15 to 22 inches diameter at the butt. The total number of piles required is 9,320.

In the construction plant layout the materials were delivered to the site over three spur tracks, although access could also be had by wagon. One of these tracks was located south of the building site, another north, and a third was placed along the longitudinal axis of the museum. The latter branches were near the mixing




plant, to permit sand and stone to be delivered along one side of it and cement along the other side.

The concrete mixing and placing plant was centrally located on the west half of the building site. The mixing plant, of the gravity type, had a capacity of 450 cubic yards per 8-hour day. The sand and stone were discharged from bottom-dump cars into hoppers located under the tracks at the south side of the plant, and from these hoppers the sand and stone were discharged onto belt conveyors, which delivered them alternately to a common bucket elevator. One at a time the aggregates were then hoisted into storage bins above the mixer.

The cement, sand and stone were discharged from their respective storage bins into a double measuring hopper, which permitted one charge to be dumped while another is being measured. After passing through the gravity mixer the concrete was discharged into a hopper located near the base of the tower. From this hopper it was discharged into a 36-cubic-foot elevating bucket, in which it was hoisted by a double drum electric hoist at a speed of 350 feet per minute.

The concrete was elevated 164 feet and automatically discharged into a 45-cubic-foot distributing hopper. This hopper was equiped with a four-way gate, to permit spouting in four directions. The total height of the hoisting tower was 180 feet.

An important feature of the concrete plant was the distributing system, which permitted the concrete to be placed rapidly and economically, without a change in the positions of any one of the four main lines of chutes. There was a fixed line of chute, 150 feet in length, leading from the distributing hopper at the top of the tower to a special form of hopper attached to the mast of each of four derricks.

It will be seen from the illustration that each line of chute was supported by hangers from a cable anchored at a distance from the tower sufficient to bring the derrick end of the fixed line of chute about to the top of the derrick when the chute was in its highest position. It was possible to vary the height of each 150-foot line of chute as the cable hangers pass through pulleys attached to the main supporting cable, and continued to the ground, where they were anchored. It also was possible to raise or lower the mast hopper, as its special construction permitted it to slide on the mast. The capacity of this hopper was about 30 cubic feet. The derricks were equipped with 60-foot masts and 55-foot booms. Each derrick was set on a concrete pier, the elevation of the top of which is 33 feet. From the mast hopper a 40-foot line of chute carried the concrete to a small hopper supported from the end of the boom. This hopper was located at the apex of a counterbalanced truss, one upper chord segment of which consisted of a 40-foot section of chute. Without changing the position of the boom it was possible to place all concrete within a 40-foot circle, or by attaching a short section of chute to the end of the truss this area could be increased somewhat. By changing the position of the boom it is evident that the possible area covered could be greatly increased. To increase still further the area served by the spouting equipment a second counterbalanced truss, similar to the first, was pivoted from the end of the first upper truss. It was then possible to place all concrete within an 80-foot circle, or by attaching a short section of chute to the end of the lower truss, this area could be still further increased.

It was thus possible to place the concrete in the entire west half of the structure from the four derricks, without shifting the position of any of them. The trusses were so well counterbalanced that one man can easily swing the end of the chute to any desired position.

This method of spouting was first used on this work, and it has proved highly successful. Although four fixed lines of chutes were provided, only three of them were in operation at one time, shifting operations being conducted on the fourth in the meantime. The investment represented by the plant was about $25,000, the cost of the tower alone being about $1,500.

# Modern Concrete Sewers and Other Structures

## Made Possible by the Use of Steel Reinforcement

THE illustration on the first page shows the details of construction of a novel reinforced concrete 72-inch outfall sewer at San Antonio, Tex., showing the electrically welded wire reinforcement in place, illustrating the perfect position and self-supporting nature of the fabric. The drawings, Figs. 1, 2 and 3, show other structures in which wire fabric reinforcement has been employed.

The concrete reinforced sewer of 72 inches diameter utilizes electrically welded wire fabric 3-inch by 8-inch mesh, with No. 0 and No. 4 wire. A similar reinforced concrete 56-inch intercepting sewer at San Antonio, Tex., is reinforced with electrically welded fabric 3-inch by 8-inch mesh, with No. 2 and No. 6 wires. This electrically welded wire fabric is a wire mesh made up of a series of parallel longitudinal wires spaced certain distances apart and held at intervals by means of transverse wires arranged at right angles to the longitudinal ones and cross-welded to them by means of a special electrical process.

It may be of interest to note some of the reinforced structures in which this form of concrete reinforcement has been used. At the Biltmore Hotel in New York city 20 acres of cinder concrete floors have been reinforced with electrically welded wire, and in the McAlpin Hotel there are 16 acres of reinforced cinder concrete floors. In the construction of the concrete coal pockets at East Forty-ninth Street, New York city, the walls of the cylindrical pocket were reinforced with 3-inch by 12-inch mesh, Nos. 3 and 8 wire being used at bottom, Nos. 6 and 10 at center, and Nos. 8 and 10 at top, while on the Sea Beach extension of the Brooklyn Rapid Transit the same construction was used also in sixteen new stations.

At South Wethersfield, Conn., a large amount of reinforced concrete pavement was laid on this system. Also in a road at West Hartford, Conn., similar wire reinforcement was used. This form of reinforcement was utilized in the erection of Ebbets Field grandstand, the home of the Brooklyn National League baseball club, for continuous reinforcement in risers and treads; also in many other grandstands and stadiums.

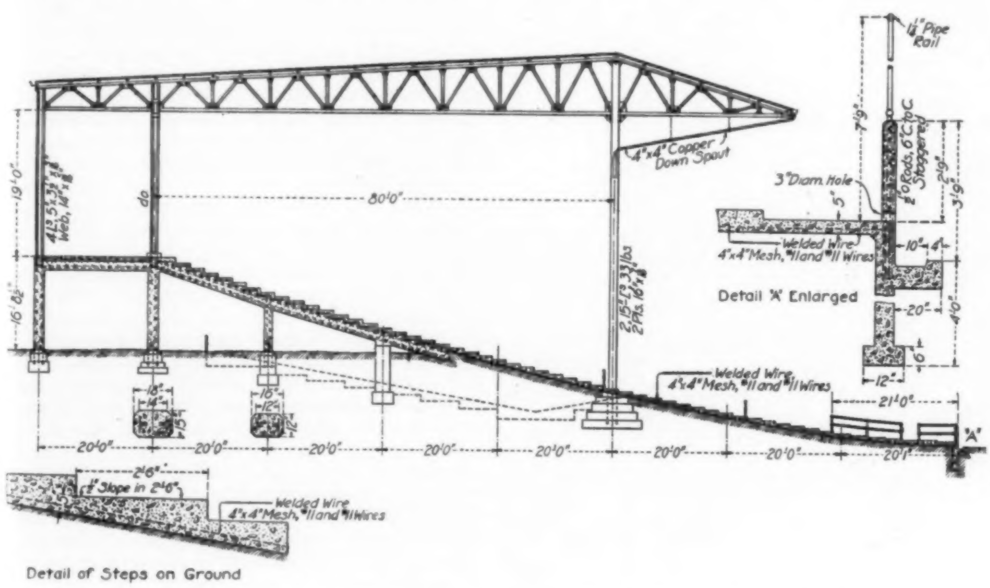



Fig. 1.—Cross section of the grandstand of the Boston National League Baseball Club.

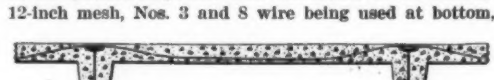


Fig. 2.—Reinforced steel beams with complete concrete fireproofing.

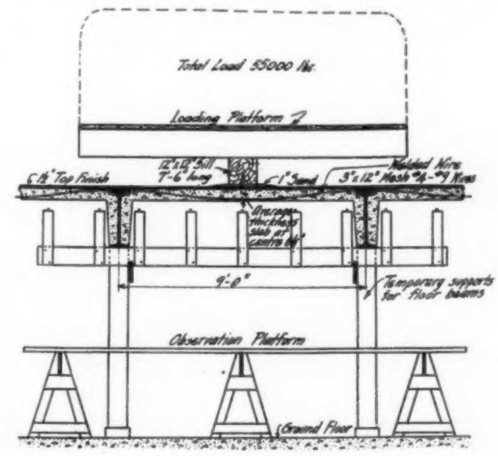



Fig. 3.—Test of a reinforced concrete floor in a garage.

Diagram showing sizes of slab and reinforcement, maximum load, and special apparatus for measuring deflections. Nine deflection points were also set at intervals of 1 foot 9 inches under the loading sill and in a line parallel with the supporting beams. Readings on these points showed deflections to exist under the load for a width of 14 feet 8 inches, whereas the length of the loading sill was only 7 feet 6 inches. The No. 9 transverse wires, extending in a direction parallel with the supporting beams, served as reinforcement in this direction and thus enabled the slab to distribute the load a considerable distance beyond each end of the timber sill through which it was applied.

### Pasteurized Milk

THAT there is no valid objection to pasteurization when properly performed, and that the process makes safer even the most carefully handled and inspected milk, is the conclusion of a new professional paper of the Department of Agriculture, in which are set forth the most recent conclusions of scientists in regard to this matter. It seems probable, says this paper, that within the next two years a large proportion of the milk supply in the large cities will be pasteurized. There is already a marked tendency in this direction. About ten years ago only 5 per cent of the milk supply of New York city was pasteurized. In 1914, 88 per cent was treated in this way. At the present time 80 per cent of the milk supply of Boston is pasteurized, and there are corresponding increases in many of the smaller cities.

Before the value of pasteurization as a hygienic measure was as well recognized as it is to-day, it was practised in secret by a number of milk dealers as a means of preserving milk and preventing it from souring. Its commerical value in this respect is undoubtedly great, but its chief function is the destruction of disease-producing organisms. Proper pasteurization should destroy about 99 per cent of all the bacteria in the milk, although when the bacterial count of the raw milk is low the reduction may be somewhat smaller. The efficiency of the process, it is pointed out, cannot be based on the per cent, but rather on the character of the bacteria destroyed.

The kinds of bacteria that remain alive after pasteurization depend on the temperature to which the milk is heated and the species of bacteria which are in the raw milk. Three processes of pasteurization, known respectively as the flash process, the holder process, and pasteurization in the bottle, are now practised in this country. In the flash process the milk is raised quickly to a temperature of about 160 deg. Fahr. or more, held there for from 30 seconds to a minute, and then cooled quickly. In the holder process the milk is heated to a temperature of from 140 deg. to 150 deg. Fahr. and held there for half an hour. When pasteurization in bottles is practised, the raw milk is put into bottles with water-tight seal caps, which are immersed in hot water and held for from 20 to 30 minutes at a temperature of 145 deg. Fahr. In this way the pasteurized milk is not subjected to any danger of reinfection. On the other hand, the seal caps must be absolutely tight and this involves increased cost. In general, it may be said that the holder process is coming into greater favor than either of the others. This process permits of the use of lower temperatures which, for various reasons, is highly desirable. Another method of pasteurization, or rather a modification of the present holder process, suggested by the Department investigators, is that of bottling hot pasteurized milk. The process consists in pasteurizing milk by the holder process at 145 deg. Fahr. for 30 minutes, then bottling it while hot in hot bottles steamed for 2 minutes immediately before filling. After filling, the bottles are capped and may be cooled by any of the systems in which the caps are protected. The bottles are sprayed with water or cooled by forced-air circulation.

When milk is held at 145 deg. Fahr. for 30 minutes, all the disease-producing bacteria, so far as can be ascertained, are completely destroyed. At the same time a larger percentage of the bacteria that cause milk to sour and a smaller percentage of those that cause it to rot are left than when a higher temperature is employed. Pasteurized at a low temperature, milk undergoes no change which affects its nutritive value or its digestibility. Subjection to a temperature of 150 deg. Fahr. or more, however, does result in certain chemical changes. Finally, pasteurization at low temperatures is more economical because the expense of heating and cooling is less.

This, of course, does not mean that insufficient pasteurization should ever be tolerated. As a matter of fact, the process of pasteurization is frequently performed improperly. For the holder process 140 deg. Fahr. is the point at which investigations have shown that disease-producing bacteria are killed, but in practice it is advisable to use a temperature several degrees above this minimum of safety. When the flash process is used, investigation has shown that very many dealers fail to heat the milk to a sufficiently high temperature. This appears to be another argument for the use of the holder process, although conditions in this respect are said to have been improved greatly in recent years.

Another common defect in the process of pasteurization is carelessness in the handling of the milk after it has been treated. As has been said already, this is one reason why pasteurization in bottles is advocated. One false step in handling the milk after it has been pasteurized will undo all the good effects of the process. The milk should be cooled as rapidly as possible to about 40 deg. Fahr. and kept at that temperature until delivered. If this is done there is only a slight bacterial increase during the first 24 hours. It has been held by some investigators that bacteria grow faster in pasteurized milk than in raw milk. This point, however, has never been thoroughly established, and other investigations indicate that the rate of increase is approximately the same.

Another objection that has been raised to pasteurized milk is that the bacteria which cause it to sour are destroyed and that without their restraining action the putrefying organisms which survive form toxins and putrefactive products in the milk. As has been pointed out this is true only of milk that has been pasteurized at a high temperature. As a matter of fact, the bulletin concludes, pasteurization by the holder process is to-day the most effective means of obtaining safe milk. This is especially true of cities which consume such great quantities that thorough inspection is almost impossible. New York city in 1912, for example, used 2,500,000 quarts a day. This was furnished by about 350,000 cows and some of it was transported more than 400 miles. One hundred and twenty-seven thousand persons, it was estimated, were engaged in handling it. Under such circumstances pasteurization is a necessary precaution. It is, however, to be regarded not as a substitute for, but as a supplement to, care and cleanliness in handling.—*Office of Information, U. S. Department of Agriculture.*

# Ocean Temperatures in the Vicinity of Icebergs*

## Investigations Made for Promoting Safety at Sea

By C. W. Waidner, H. C. Dickinson, and J. J. Crowe

THROUGH the courtesy of the Navy Department an opportunity was afforded to the representatives of the Bureau of Standards to make observations on the temperature of sea water in the vicinity of icebergs and in the open sea with a view to obtaining information on the possibility of detecting the proximity of ice from temperature records. It is fairly evident from a long experience of navigating officers that the usual methods of taking the temperatures of sea water at widely separated intervals of time can give no useful information so far as detecting the proximity of icebergs is concerned. If any variations in the temperature are caused by the presence of ice, then continuous records of the temperature should be taken. The object of these experiments was to obtain such records and then to carefully analyze them with the view to ascertaining whether the proximity of icebergs gives rise to any definite temperature variations which can be distinguished from the accidental variations usually found in sea water.

The Bureau party embarked on the U. S. S. "Chester," leaving Philadelphia on June 2nd, 1912, under command of Capt. Decker. Mr. Crowe subsequently transferred to the U. S. S. "Birmingham," under command of Capt. Hughes, and continued observations from June 19th until the return to the port of Philadelphia on July 11th, 1912.

### TEMPERATURE EQUIPMENT.

The apparatus assembled for these experiments consisted of the following:

One electrical resistance thermometer with 50-foot leads, and one with 150-foot leads, protected and insulated by 4-ply rubber hose, the longer hose being reinforced with wire rope (the thermometers were of the Callendar compensated type with four flexible copper leads and coil of silk-covered nickel wire of about 100 ohms resistance); a surface electrical resistance thermometer, consisting of a flat coil of silk-covered nickel wire inclosed between copper sheets and insulated by thin layers of mica (the resistance of the nickel coil was about 100 ohms); deep-sea thermometers of the Negretti & Zambra type, kindly loaned by the Bureau of Fisheries; several standard mercurial thermometers; a Leeds & Northrup recorder suitable for use with the resistance thermometers, and which was kindly loaned for these experiments by the Leeds & Northrup Company; a Siemens & Halske Wheatstone bridge; a Leeds & Northrup Wheatstone bridge with Kohlrausch slide wire; a Leeds & Northrup marine D'Arsonval galvanometer; a Siemens & Halske high-resistance millivoltmeter; tools, wire, repair parts, etc.

All of the apparatus was carefully calibrated before leaving the laboratory.

The surface thermometer was mounted with its flat face directly against the inner surface of the ship's ⅜-inch plates, about 6 feet below the water line. The location of the thermometer was in the torpedo room, forward, and on the starboard side. The thermometer was held into good contact with the plate by a suitable wooden strut which was thermally insulated from the thermometer by a layer of felt, and the whole protected by a thick layer of cotton to eliminate the effects of the temperature of the torpedo room. Special experiments showed that this thermometer responded quickly to changes of temperature of the surface with which it was in contact. Simultaneous measurements of temperature made with a sensitive mercurial thermometer in the injection water and with the surface thermometer and recorder, mounted as above, showed that the sudden changes in sea-water temperature were indicated by the recorder without any significant time lag. As an additional check on the calibration of the surface thermometer it was compared frequently with standard mercurial thermometers.

The recorder was mounted on both ships in the torpedo room near the surface thermometer. The suspended system of the D'Arsonval galvanometer of this recorder was so carefully balanced by the makers that the records were entirely unaffected by the rolling and pitching of the ship, which was by no means inconsiderable, the rolling sometimes amounting to 20 degrees to 30 degrees on each side of the vertical. As used, a change of 1 degree Cent. corresponded to a movement of the pen of 18 millimeters on the record sheet. The displacement of the paper was about 60 millimeters per hour. Full details of the operation of this recorder have been published in the current engineering literature and may be had from the makers. This recorder, with the surface thermometer above described, gave such excellent satisfaction that it was not necessary to use any of the other apparatus which was taken on the trip for emergency use.

### TEMPERATURE RECORDS.

Practically continuous temperature records were obtained from June 4th until July 10th, 1912. The temperatures recorded ranged from 3 deg. to 25 deg. Cent. The balance point of the recorder was changed to bring the temperature records on the paper by the insertion of suitable known resistances in one arm of the Wheatstone bridge circuit of the recorder, the calibration of the surface thermometer being made with the corresponding resistances in the circuit.

About 5.25 P. M. the ship lay-to abeam of a berg at a distance of 300 yards. A party put out in a small boat for temperature observations. The time until 7 P. M. was spent in the immediate neighborhood of the berg, the ship sailing around the berg while the party in the small boat were taking observations. From about 7 to 9.30 P. M. the ship lay-to; by this time the ship and berg had drifted apart. During the remaining time, until about midnight, the ship cruised around in an unsuccessful effort to locate the berg with the aid of two powerful searchlights.

From measurements made with two stadimeters, on the ship and on the whaleboat, respectively, the dimensions of the berg were determined. The mass of ice in this berg was thus estimated at about 400,000 tons.

The mean of a number of temperature observations taken from the whaleboat gave the following surface temperatures: 20 feet from the berg, 4.5 degrees; 35 feet, 4.9 degrees; 50 feet, 5 degrees; 75 feet, 5.4 degrees; 200 feet, 5.7 deg. Cent. The temperature at a distance of 50 feet from the berg and at a depth of 5 fathoms was 3.6 degrees, and at a depth of 20 fathoms 3.3 degrees. At some miles distant from the berg temperatures were encountered as low as those observed a few feet from the berg.

Although the effort to locate the berg with the aid of searchlights was unsuccessful, at daybreak on the morning of the 18th the berg was in plain view. Between 6 and 7 A. M. the berg turned over in an interval of about 10 minutes, accompanied by several loud reports similar to the reports caused by firing 3-inch guns.

On the morning of June 18th some time was spent in experiments to detect possible echoes, submarine and aerial, which are referred to elsewhere.

### VARIATIONS IN THE SALINITY OF SEA WATER.

Variation in the salinity of sea water in the neighborhood of icebergs due to the diluting action of the water resulting from the melting of the ice is so small as to be entirely masked by the accidental variations found in sea water. The following determinations of the densities of samples of sea water, taken under conditions specified and which were afterward tested in the laboratories, will serve to illustrate this:

| Sample. | Specific Gravity at $\frac{20°}{4°}$ C. | Remarks. |
|---|---|---|
| 1 | 1.02339 | Close to berg |
| 2 | 1.02352 | Close to another berg |
| 3 | 1.02340 | 400 yards from berg |
| 4 | 1.02336 | 40 miles from berg |
| 5 | 1.02319 | 60 miles from berg |
| 6 | 0.99923 | Water from berg ice |
| 7 | 0.99923 | Distilled water |

### ECHOES FROM ICEBERGS.

The testimony of numerous observers is in evidence that the echo of the foghorn may frequently, but by no means always, be detected when in the proximity of an iceberg or even of a bank of fog. The amount of evidence on this point leaves no doubt as to the correctness of the above statement. The experiment of sounding the foghorn when in the vicinity of a number of the bergs encountered on the trip was tried, but in no instance was an echo detected.

A few experiments were also made to determine whether an echo could be detected under water coming from the larger submerged portion of the berg. For this purpose the ship's bell was lowered into the water and signals produced by striking the bell. Observers stationed at the ship's submarine signal telephones listened for evidences of the echo. The ship was at a distance of 1 to 2 miles from the fair-sized berg encountered by the U. S. S. "Chester" on the afternoon of June 17th. It was difficult to draw positive conclusions on account of the disturbing noises present in the telephone receiver, but a number of observers were convinced that they heard faint echoes. There was no time to investigate and improve the telephonic apparatus, so that the most that can be said is that these preliminary experiments looked hopeful enough to merit more careful experiments along these lines.

### OTHER OBSERVATIONS.

The results of other experiments, such as firing 3 and 5-inch shells into the berg, the utility of searchlights in locating bergs at night, etc., will undoubtedly be covered in the official reports of the commanding officers. It may be worth while to record, in passing, for the information of the reader, the general impressions of the authors, unfamiliar with such matters, that the effects of cannon fire in breaking up icebergs were disappointingly small and the utility of powerful searchlights in their location surprisingly limited.

Although the lookouts were provided with spyglasses or with binoculars, it is of interest to note that the icebergs were invariably first seen with the unaided eye. The difficulty of picking up icebergs under some conditions is illustrated by the following incident: While the ship was steaming toward a large berg in sight a heavy fog fell. There was one lookout in the crow's nest, four on the bridge, and two in the ship's eye. Notwithstanding this the berg was first picked up from the quarter-deck after the ship had passed some 200 yards abeam.

Samples of ice broken from the berg by gun fire were taken aboard ship. These contained considerable amounts of included air, which probably accounts for their white appearance. The ice was surprisingly hard and free from any definite cleavage planes. The whitish appearance was generally characteristic of all the bergs met with. In some instances there were narrow streaks of ice, transparent and of a blue color, that penetrated entirely through the bergs.

The water resulting from the melting of the berg ice was found to have the same density as that of distilled water. It was free from any characteristic taste.

So far as our observations go, the temperature of the air furnishes no evidence of value as to the proximity of a berg.

### DISCUSSION OF OBSERVATIONS.

An examination of the temperature records, which were obtained under a variety of conditions in the region 37 degrees to 43 degrees 30 minutes north laditude and 43 degrees to 53 degrees west longitude, at once impresses one with the difficulty of separating the large and sudden variations of sea water temperature, so frequently met with, from any variations that may be caused by the proximity of icebergs. The authors have obtained records in some parts of the ocean in which the temperatures were practically constant to a few tenths of a degree for many hours. On the other hand, some of the sample records show that the temperature variations in other parts of the ocean, where no ice is near, are as great and as sudden as any observed in the neighborhood of bergs. Having established the existence of such variations in sea water temperatures, it follows that it will be very difficult and often impossible to draw definite conclusions as to the proximity of ice from temperature records.

In approaching or leaving a berg the temperature of the sea water may rise or fall or remain practically constant. Thus in approaching the large berg along our course the temperature varied irregularly through a range of about 0.2 deg. Cent., a variation much less than is frequently observed in this distance. Along some of the courses the temperature fell in approaching the berg and along one course the temperature varied quite irregularly.

The temperature records published by Prof. Barnes very generally show a rise in temperature as a berg is approached, occasionally accompanied by a slight fall in temperature very near the berg. Prof. Barnes regards the rise of temperature as the "characteristic iceberg effect" and attributes any drop in temperature to cold currents. His records show the normal variations of sea water temperature in the localities of his observations to be very much smaller than were observed in the parts of the ocean where our observations were made. Although many of the small temperature variations which appear significant in his records would be completely masked by the large and sudden temperature changes which our records show, nevertheless the magnitude of the so-called "iceberg effect" observed by Prof. Barnes being often 0.5 deg. to 2 deg. Cent., such changes would be very evident on our records where changes of a few hundredths of a degree are readily discernible.

Our records do not corroborate Barnes's characteristic

* Abstracts from *Bulletin of the Bureau of Standards*, Vol. 10, No. 2.

iceberg effect. Twelve of the fourteen curves obtained, as well as the mean curve, certainly show no such rise in temperature. Most of these curves indicate the opposite effect.

As Prof. Barnes's and our own records are matter of observation which unquestionably represent conditions that were actually encountered, it would seem that the effects due to bergs, if such effects can yet be regarded as established, must be different under different conditions. Indeed, that such is the case is shown by the different temperature records obtained in approaching a given berg along different courses.

Enough data is not yet at hand to formulate a theory to account for the variations of temperature observed in the vicinity of icebergs. Indeed, the question is still in doubt as to whether they influence to any measurable extent the temperatures of sea water at any considerable distance (a mile or so).

In view of the observations of Barnes and of the authors on the salinity of surface water at different distances from bergs, it seems fairly certain that the layer of cold, fresh water resulting from the melting of the berg, and which was supposed on Pettersson's theory to spread out over the surface in the vicinity of an iceberg, causes no measurable dilution or change of salinity of the surface layer.

Barnes's records so uniformly show a rise of temperature as the berg is approached that he has termed this observed rise "the iceberg effect." This effect is not characteristic of our records. Indeed, on the average, the authors observed a fall in temperature from a distance of several miles up to the bergs. In view of the erratic variations of the temperature of these parts of the ocean when no ice is near and of the fact that in approaching a given berg along different courses the temperature variations are quite different (being nearly constant over some courses and falling very appreciably over other courses), we would not deem it justifiable to conclude that the observed variations were certainly connected with the presence of the bergs.

It is interesting to inquire a little further into the question whether any cooling action of the berg could be expected to make itself felt at any considerable distance from the berg. If the berg is constantly drifting into new waters, such effect would obviously be impossible from the consideration of the fact that it would require the melting of about a million tons of ice to cool 1 square mile of the ocean to a depth of only 25 feet by 1 deg. Cent.; hence the possibility of any significant cooling action would require that the berg and the water in which it is immersed drift together for a considerable period of time, i. e., that the relative motion be small. This is probably true under some conditions, but by no means always. Considerations, such as these, of the enormous mass of ice required to produce a cooling action distinguishable from temperature variations due to other causes, the slowness of melting of the berg, etc., render it doubtful whether any such effect could be distinguished with certainty at distances of a mile or so. To account for the observed rise in temperature or "iceberg effect" Barnes has advanced an ingenious theory. He assumes that in regions of the ocean at some distance from the berg the surface layer, heated by solar radiation, is mixed with the colder water below by the "normal vertical circulation," while near the berg there is a current set up toward the berg due to the combined effects of the melting and cooling action of the berg. This current toward the berg, it is assumed, interferes with the "normal vertical circulation" so that the warm water remains on the surface. It is difficult to understand how a sufficiently strong current toward the berg could be set up by the melting and cooling action of the berg to interfere with the "normal vertical circulation" at a distance of a mile or two. That there is no very strong current toward the berg seems to be indicated by the drifting apart of the fragments of a berg from the berg itself or of the larger parts of a berg after breaking up. Difference of wind action may, however, complicate any conclusions based on such observations.

CONCLUSIONS.

The records of sea-water temperatures obtained by means of an electrical resistance thermometer and a Leeds & Northrup temperature recorder, installed on the U. S. S. "Chester" and "Birmingham" in their patrol of the North Atlantic Ocean in June and July, 1912, show that the temperature variations in parts of the ocean far removed from ice are often as great and sudden as in the neighborhood of icebergs.

For a majority of the courses of the ship in the vicinity of icebergs there was a fall in temperature from a fraction of a degree to 3 degrees in a distance of 4 or 5 miles on approaching the berg. Records were obtained, however, in which the character of the temperature variation varied with the direction of approach to the berg, the temperature being nearly constant over one course, while over other courses the temperature rose or fell as the berg was approached. So far as our records go, therefore, it does not seem possible to draw positive conclusions as to the absence or proximity of ice from the temperature records of sea water. This is not a condemnation of the use of suitable recorders on ships. As Barnes has shown, the temperature record may give valuable information on the approach to shore and shallow water, on the identification of characteristic ocean currents, and, as his records seem to show, even of the proximity of icebergs in some parts of the ocean where the variations are less erratic than in the regions in which our observations were made.

If the "characteristic iceberg effect" observed by Barnes, i. e., rise of temperature on approaching icebergs, had been present around the bergs observed by us and of the same or even much less magnitude, our records would have rendered such an effect evident, notwithstanding the irregular variations of temperature usually found to exist. In view of the differences in the character of the records obtained by Barnes and ourselves, it is very desirable that further observations be made in different parts of the ocean, and under as varied conditions as possible, before attempting to draw final conclusions.

## Gelatine As a Food for the People*

**By Ernst Homberger**

IT HAS been suggested in various places since the war began that gelatine would prove an excellent substitute for meat. This is an extract of a nitrogenous substance composed of bones and calves' heads and feet. Exhibitions of gelatine foods have been held in Berlin, Frankfurt-am-Main, Mannheim, Osnabrück, Stuttgart and other places.

It is certainly not by accident that the common people have often been kept alive by gelatine when other food stuffs were lacking. This is best proved by the fact that people turned to gelatine as a substitute for meat during the siege of Paris in 1870-71, that at several meetings of the Academy of Science famous authorities declared themselves in favor of gelatine as food material, and that the French government seized all bones for food for the besieged.

The first one in Europe to be interested in gelatine was Denys Papin, 1681, the celebrated inventor of the digestor. He conceived the idea of extracting gelatine from bones by boiling under strong pressure. He proposed to King Charles II of England to prepare 150 pounds of gelatine in twenty-four hours with the consumption of 11 pounds of coal. He wanted thus to solve the problem of turning three oxen into four. Some wags hung a touching petition about the necks of the king's dogs, begging that the one thing that had been left to them by man should not now be taken away from them, and behold his Majesty was so touched that their right to bones was graciously left to them for the time being.

When after the French Revolution interest was taken in improving the food of the soldiers and poor people, and attention was again directed to gelatine, methods of producing gelatine were proposed by Proust, d'Arcet, Peletier, and Cadet de Vaux. At that time they judged the food value of a substance according to its content of nitrogen and its solubility; and gelatine was regarded as the only nutritious part of the meat and bone. It was thought that cheap gelatine would make a good substitute for meat and animal substances. The bones, according to this view, contained much more nutritious material than meat. Great worth was attached, therefore, to a glutinous bouillon of meat or bone.

By order of the Institute of France Guyton-Morveau and Deyeux, of the First Gelatine Commission, were required in 1802 to consider a report presented by Cadet de Vaux over the preparation of food from bone. The commission admitted that gelatine had nutritive qualities, that in certain cases it might even take the place of meat, but it did not regard it as established that the nutrition of any food could be measured only by the amount of gelatine it contained.

The Academy of Medicine of Paris had been asked in 1814 by the Société Philanthropique whether, and to what extent, gelatine was nutritious, and whether its use as food was conducive to health. The Academy regarded it as fully established that gelatine was a strengthening food, that it made meat broth nutritious and that it was the most nourishing of all animal matter. Thereupon its use became widespread in the public institutions of Paris and throughout France.

D'Arcet devoted thirty years of his life to getting gelatine used for a food for the people, actuated solely by the ideal of improving the lot of the poor and needy. Under his influence it was introduced into hospitals.

In Hotel St. Lazarre no less than two and three quarter million orders were served in the years 1829 to 1838. D'Arcet succumbed in a battle for a good cause. In the institution in which the soup was prepared according to his directions it was liked. But where it was carelessly prepared it was nauseating.

Scientific investigations such as were carried on by Donné failed because people did not know at that time exactly how questions of this sort should be decided.

This fault must also be laid at the door of the second commission which under Magendie experimented with gelatine on dogs. The chief fault of the commission was that it thought a substance refused by an animal because of its taste could not have food value, and further that it did not prescribe the quantity to be consumed by the animal. The commission observed insufficient nourishment; and this held not only with the rations of gelatine, but also when bread and meat were added. The commission set dry gelatine before the dogs, which they naturally refused to eat. Moreover, these creatures were kept in cages in a cellar. It was, therefore, no wonder that the experiments of the second gelatine commission were wholly negative in their results and that the commission ascribed no value to gelatine as a food product.

The previous exaggerations of the value of gelatine were now followed as the result of this opinion of Magendie by just as unjustified a reaction, in which no food value was ascribed at all to gelatine.

Frerichs, who was occupied in Germany with the same matter, objected to these experiments on the ground that the exact proportions of different food stuffs were not given, that the food given may not have contained the necessary organic and inorganic constituent parts, and that the animals failed because certain food stuffs were lacking and not because gelatine had no food value.

Mulder, too, refused to admit that Magendie's experiments were convincing, and says rightly: "In fact, the experiment which Magendie made with sugar proved that sugar has no food value. Everybody admitted this result and yet sugar is rightly classed among food stuffs." The same thing will be found to be true of gelatine.

Experiments had also to be made to find out how the white of an egg and a solution of fat would behave under the influence of gelatine and whether gelatine would have any influence upon them at all.

It has been shown from the experiments of Bischoff and Voit that gelatine is dissolved as it goes through the cells with a nourishing fluid, and really dissolves more easily than albumen, which keeps it somewhat from solution. Gelatine saves albumen to a much greater extent than fat and carbohydrates; one hundred parts of gelatine taking the place of fifty parts of albumen. By greater proportions of gelatine, along with fat or carbohydrates, the loss of albumen in the body is much reduced; but it is never possible to safeguard the body from all loss of albumen; some nitrogen or albumen is always consumed. To the gelatine must always be added a small quantity of albumen in order to maintain the proper amount in the body. Moreover, by supplying gelatine somewhat less fat is consumed.

According to Munk the importance of gelatine consists in this, that it is dissolved very quickly and completely in the cells and by its solution saves the albumen from solution. This quality of saving the albumen is an exceedingly important one and at least twice as great as that of carbohydrates and fats. One hundred grammes of dried gelatine take the place of 31 grammes of albumen (150 grammes of meat). Moreover, the consumption of fat is reduced by gelatine. Five-sixths of the albumen used can be replaced by gelatine. Accordingly gelatine represents a very valuable food product, which becomes of greatest importance where used for the economy of albumen.

It is, therefore, desirable that the value of gelatine as a food for the common people should be more and more recognized. If, besides gelatine, a certain amount of albumen is supplied to the body, and a certain amount of fats and carbohydrates to prevent the loss of fat, the normal condition of the body can be maintained. Because of its albumen-economy and fat-saving effects, and the ease with which it is digested, two men, Senator and Uffelmann, regard it as a valuable addition to fever diet. With the low appetite of sick people and the distaste for meat one can protect the body against loss of albumen by supplying gelatine.

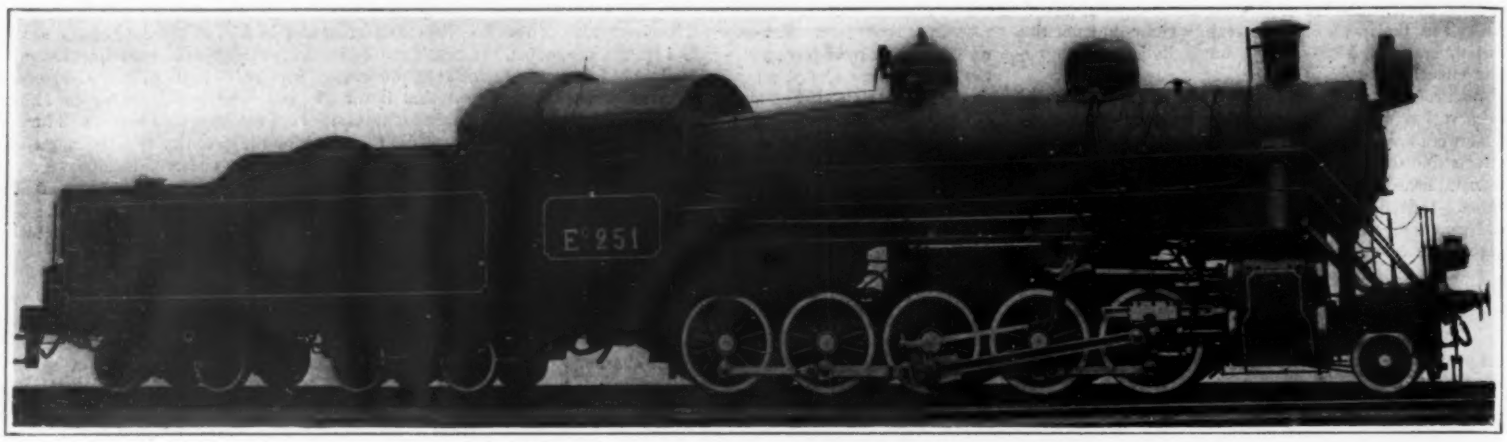
The taste is improved by the addition of spices. Some sheets of gelatine put into a good soup is an easily digested and very nourishing dish. When at the siege of Paris the cannons were thundering outside the defenses, the Academy was occupying itself with questions of food. Dumas, who had been a member of the second gelatine commission, and Fremy, pointed to the extraordinary importance of gelatine as food, and to D'Arcet, in his grave, justice was done for the great part he had played in introducing gelatine.

In like manner one should return during this world war to the idea of gelatine as material of the highest value for inexpensive food stuff for the masses.

* From *Die Umschau*.

## Gathering Food for Bees

A CLEVER scheme, that appears to have originated in Scotland, is to gather pollen from flowers with a vacuum cleaner for use as food for bees. The heather on wide stretches of moors provides ample supplies, and it is said that in some places the young bees were mostly reared on this pollen.



Powerful locomotive built in America for a Russian Government line.

# American Built Locomotives Abroad

## Many Styles Necessary to Meet Foreign Requirements

ALTHOUGH the locomotive builders of the United States have been doing business with European countries for many years, the exigencies of the war have brought many orders for motive power to this country during the past year, both for replacing material destroyed in the conflict and for fitting out new lines and engines of special designs for military purposes. In all of these instances the locomotives furnished have been in the nature of composite design, American ideas and practice being adapted to and combined with certain requirements and specifications of the purchasers, and for this reason the accompanying illustrations and descriptions of details will be of general interest.

The illustration at the top of this page shows one of a number of large engines that have been supplied to Russia for use on the Russian State Railways, and are probably doing service on the new Archangel line. This engine is built for a gage of 5 feet, which is the standard gage on the more important lines of Russia, and it is guaranteed to haul under favorable condition, on an 0.8 per cent grade without curves, a train of 1,000 tons in fully loaded cars at a speed of 12 to 15 versts (7.96 to 9.95 miles) per hour.

American practice is followed in the design with the exception of the proportion between weight and tractive power; this engine has exceptional power for the weight limitations imposed. The total weight is 190,000 pounds, and the weight of drivers is 174,000 pounds. The cylinders are 25 inches by 28 inches, driving wheel diameter 52 inches, and steam pressure of 180 pounds, which gives a tractive power of 51,500 pounds, and a factor of adhesion of 3.39. This factor of adhesion is considerably less than what would be considered as good American practice, but European engines do not work at the same cut-offs as used in this country. This reduces their figure for tractive power and necessarily increases the factor of adhesion.

Another illustration shows a powerful Siberian Government Railway locomotive built in America.

These Mallet engines have a total weight of 126,000 pounds, and the cylinders are 13 inches and 20½ inches in diameter by 20 inches in stroke. The driving wheels are 36 inches in diameter, and the steam pressure is 200 pounds. They are fitted with the American system of compounding, and have a tractive power working compound of 24,300 pounds and 29,200 pounds working simple. The boiler is of the straight top type, 52 inches in diameter at the front end, and has 157 2-inch tubes, 15½ inches in length. By means of a brick wall a grate 85 inches long by 39¼ inches wide is installed in a firebox 114⅛ inches long by 39¼ inches wide. A screw reverse gear was also applied.

The consolidation engine shown has a total weight of 80,500 pounds, the cylinders are 15 inches in diameter, and are 20 inches in stroke, the steam pressure being 160 pounds, and the locomotive has a tractive power of 17,000 pounds. The boiler is of the straight top type, 47⅞ inches in diameter at the front end. It is fitted with 126 2-inch tubes, which are 15 feet 1½ inches in length, and it has a firebox 48 3/16 inches long by 39¼ inches wide. Both of these locomotives are built to work on lines having a 30-inch gage.

Interurban locomotive built in America for Belgium.

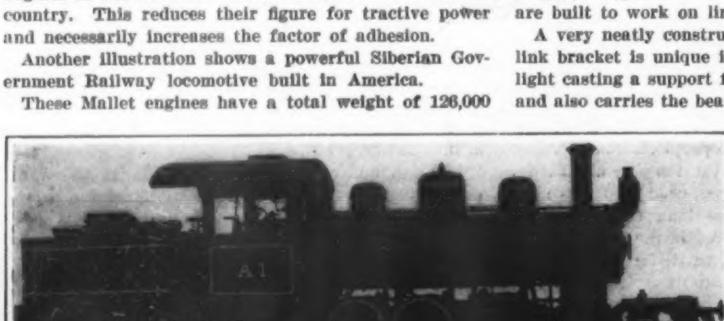
A very neatly constructed link bracket is used. This link bracket is unique in that it forms in a small and light casting a support for the link, back end of guides, and also carries the bearing for the reverse shaft. The connections on front and back knuckle pins are made by ball joints. This eliminates the bending strain on side rods when engine is on curves. Lateral motion on first and fifth drivers will allow engines to operate on curves up to 700 feet radius on main line, with a possibility of entering curves of 300 feet occasionally. Other features included are I-section guides, outside steam pipes, extended piston rods, air-operated screw reverse gear, Zara throttle and pyrometer, also radial buffer and Franklin firedoor, as well as LeChatelier water brakes on fifty engines and Russian Westinghouse brakes.

The other locomotive illustrated shows one of fifteen for Peter the Great Fortress Reval, and attention is called to the fact that this was an entirely new design, but followed American practice.

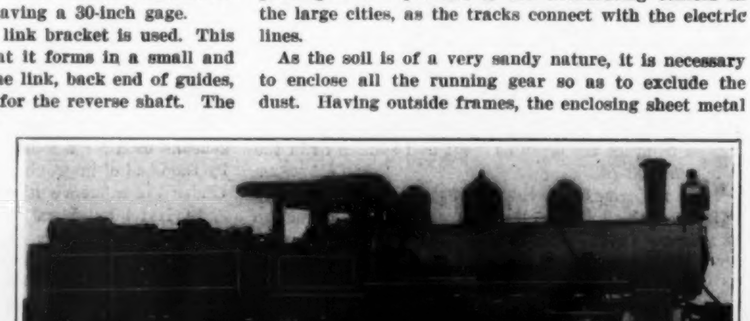
These engines have a gage of track of 750 millimeters (29.53 inches). They have cylinders 11 inches in diameter by 16 inches in stroke, and the boiler pressure is 165 pounds. They are provided with driving wheels 33½ inches in diameter, the engine having a tractive power of 8,100 pounds. The boiler is of the straight top type, is 36⅝ inches outside diameter at the front, and contains 85 2-inch tubes, 10 feet 6 inches long. The firebox is 40½ inches long and 33 inches wide and burns soft coal. The tender is of the four-wheel rigid pedestal type and has a capacity of seven hundred gallons of water and one and one half tons of coal.

An interesting machine is the novel Belgian State Railway locomotive, which is one of twenty unique designs built in America. In Belgium overhead trolley wires are not allowed, and, while electricity is used in the cities, all interurban traffic is handled by small steam engines of unique design. These engines haul passengers and produce to the distributing centers in the large cities, as the tracks connect with the electric lines.

As the soil is of a very sandy nature, it is necessary to enclose all the running gear so as to exclude the dust. Having outside frames, the enclosing sheet metal



American built narrow gage locomotive used in Russia.



An American consolidation locomotive for Serbia.

**An American built Mallet compound locomotive for Serbia.**

runs from the bottom of the frames to the bottom of the side tanks, and five swinging doors on each side allow access to the moving parts. These engines are also arranged for operation from either end. The throttle and reverse lever handles are fitted with a steel link which holds the latch levers in an open position when engine is being operated from the opposite end.

The gage of track is 39⅜ inches, and the engines have a total weight of 58,900 pounds in running order, with cylinders 11½ inches in diameter and 16 inches in stroke, and driving wheels 34 inches in diameter. The steam pressure is 180 pounds, and they have a tractive power of 9,520 pounds.

The boiler is of the Belpaire type, 42 inches in diameter at the front end, and is designed to burn coal briquettes. It is fitted with 144 tubes, 1½ inches in diameter and 6 feet 4 inches long. The firebox is 42 inches long and 28¼ inches wide, and is designed so as to drop between the frames for repairs. Ten engines have steel tubes and steel fireboxes, and the other ten have brass tubes, copper fireboxes and copper staybolts. A hand-operated automobile horn is installed on each end.

The boiler has a heating surface for both tubes and flues of 354 square feet, the heating surface firebox being 30 square feet, so that the total heating surface is 393 square feet, with a grate area of 3.2 square feet.

## Currency in China

THE trade of China is hampered by one of the most confused and chaotic systems of currency, on a silver basis, in the world, the intricacies of which are understood by comparatively few people. Theoretically the tael is the unit of currency for foreign and Chinese commerce, and is subdivided decimally into mace, candareens, and cash (1 tael = 10 mace, 1 mace = 10 candareens, 1 candareen = 10 cash). It, however, is not a coin, but a weight of silver of a certain degree of fineness, and it varies in weight, in touch, and in value in different parts of the country. Every commercial center in China not only has its own tael weight, but several standards side by side. The tael of weight is the liang, or ounce, of China, and 16 taels make 1 catty, or Chinese pound (1⅓ pounds avoirdupois).

THE VARIOUS TAELS IN CIRCULATION.

Of the numerous taels of currency, two may be considered as being in universal use, the haikwan, or "customs," tael and the kuping, or "treasury," tael; a third, the tsaoping, or "tribute," tael, is current over a considerable part of the country. The haikwan tael is the currency in which tariff duties imposed by the Maritime Customs are levied, but it is a purely fictitious currency and at no port does a merchant tender haikwan taels in payment of duties; instead he pays in local currency at a rate of exchange settled upon at the opening of each of the several customs offices. At Shanghai the rate of conversion is fixed at 100 haikwan taels = 111.40 Shanghai taels. The Shanghai tael contains 524.93 grains of pure silver, which makes the haikwan tael the equivalent of 584 grains. Due allowance, however, must be made for the quality, or "touch," of the silver. When the merchant does not have at hand the fine silver (992.3 fine) for the payment of duties, he must obtain it from a banker by private arrangement. The value of the haikwan tael in foreign currency is fixed monthly by the Maritime Customs authorities. In 1914 the average value in American currency was $0.67.

The kuping tael is the currency in which all dues to the Government except customs duties and those which are levied in kind or copper cash are paid. The standard kuping tael is 575.8 grains of silver, 1,000 fine, but there is a variation in some cases as much as 1 per cent in different parts of the country. Where the foreign obligations of the Chinese Government are concerned, the equivalent of the several currencies is 100 haikwan taels = 101.64235 kuping taels, and 100 kuping taels = 109.60 Shanghai taels.

The tsaoping tael is current in Provinces which pay tribute in kind (mainly rice), and it is also in use at Chefoo. Subject to slight variation, it weighs 565.65 grains. As a tael of currency, it is based on different standards of silver. The standard at Chefoo is 976, at Kiukiang and Wuhu 994, at Hangchow 997, and at Shanghai 999.

Apart from the various Government taels, every commercial place has several local taels, all generally recognized and all current. Usually among these various taels there is one which is recognized as the currency of the place, in which payments would be made when there is no stipulation to the contrary. In Peking there is no one recognized tael, but the Tientsin tael of 557.6 grains of silver, 992 fine, is the generally accepted tael at Tientsin; the Hankow tael of 554.7 grains of silver, 967 fine, at Hankow; and the Sze-ma, or Canton tael, of 579.85 grains of silver (theoretically 1,000 fine, but in practice of a lower degree of fineness), at Canton.

At Shanghai the Canton tael is used for dealings in foreign bar silver, the tsaoping tael for Chinese remittances through Chinese banks to places in China, and the Shanghai tael, or "Shanghai convention currency," for local banking and trading purposes. The value of the latter is made up of three elements—the weight, the quality of silver, and a convention. The weight on the scale is 524.93 grains, the silver is reduced to a standard of 944 fine, and the convention is that 98 taels of this weight and this silver settle a liability of 100 taels Shanghai convention currency. At the present time (June, 1915) the value of the Shanghai tael in United States currency is $0.55.

SILVER SHOES (SYCEE) AND COPPER CASH.

The silver in China is most commonly current in oval ingots called "shoes," which weigh from 5 to 50 taels, and the silver in the shoe is known as "sycee." In the interior of the country, outside the treaty ports and among the mass of the population, silver is not extensively circulated and is used mainly for the purpose of hoarding. Frequently the Chinese who secure silver coins melt them up into sycee. But when very large payments are made, the shoes of sycee are employed and they are accepted at their actual weight and degree of fineness.

The real currency of the people of China is the copper cash, one of which equals one one thousandth part of a tael. This is its theoretical value, but in practice the value varies from 800 to 1,800 or 2,000 cash to the tael, and it is not uniform throughout the country. Cash (from the Sanskrit "kārsha") are small round coins with a square hole in the center and they are strung on strings in rolls of 100, of which 10 go to the string, or "tiao." The money changers usually deduct 1 to 4 cash for their trouble in stringing and for the string. In Shanghai at the present time the Shanghai tael is worth 1,925 cash, whereas a year ago it was worth only a little over 1,700 cash. The depreciation in the value of the cash has a very serious effect on the mass of the people and considerably restricts their purchasing power. A piece of gray sheeting, for example, may be quoted in an interior city at 4 taels. The native, at the present rate of exchange, would have to pay 7,700 cash for the piece as compared with only 6,800 cash a year ago. In addition to the 1-cash piece there are 10-cash copper coins, or cents, which, however, are not always exchanged at their face value.

FOREIGN COINS—CHINESE DOLLARS—CURRENCY REFORM.

The growth of foreign trade and the objection of the foreigners and merchants in the treaty ports to carrying around the heavy silver sycee, or shoes, and cash, led to the introduction into China of a number of foreign coins of which the principal ones were the Carolus, or Spanish, dollar; the Mexican, or eagle, dollar; and the Japanese yen, or dollar. Of these the Mexican dollar is in most general use and it is current in many of the treaty ports of China. Its exchange value is expressed in relation to the tael. At the present time the rate of exchange is 100 Mexican dollars = 72.80 Shanghai taels. Taking the Shanghai tael at $0.55 United States currency, this makes the value of the Mexican dollar about $0.40.

The Chinese have also issued 10 or more different kinds of dollars, but their great disadvantage has been that they are at a discount in all the Provinces except the one in which they are minted. There are also in circulation a number of subsidiary silver coins known as 10-cent and 20-cent pieces, which are nominally fractional parts of a dollar but are stamped with a tael value, the 10-cent piece, for instance, being stamped as 7.2 candareens. The ratio which these coins bear to the dollar varies considerably. At times ten 10-cent pieces and four 10-cash pieces, or 114 cents, may be obtained from a money changer for a Mexican or Chinese dollar, while at other times only ten 10-cent pieces are given in exchange. In recent years the provincial mints in China have been permitted to issue silver and copper subsidiary coinage for purposes of revenue, and this has led to an enormous overissue and consequent depreciation in the value of these coins.

In January, 1914, a new regulation went into effect by which it is hoped that some measure of reform in the currency of China may be effected. Under this regulation the right of minting and issuance of national currency is confined to the central Government. Provision is made for four kinds of silver coins, the yuan or dollar, the ½-yuan, 20-cent pieces, and 10-cent pieces; one kind of nickel coin, the 5-cent piece; and five kinds of copper coins, the 2-cent piece, the 1-cent piece, and one half, one quarter, and one sixth of a cent pieces. In order to facilitate the carrying out of the provisions of the act, the Government is melting up all the dollars formerly in circulation that are received in payment of taxes and replacing them with the new standard dollars, which are made legal tender throughout the country. Every effort is being made, through the large Chinese banks and governmental support, to give to the new coins a fixed and uniform value in all parts of China, and it is expected that they will gradually replace the numerous kinds of money now in circulation that add to the confused and chaotic state of the country's currency.

PAPER MONEY IN CIRCULATION.

Paper money has been issued from time to time by the central or provincial governments and by private individuals and banks. Formerly there was little restriction on the amount that could be issued, and the large quantity of notes in circulation that in financial crises the banks frequently could not redeem has caused them to depreciate in value or to become practically worthless. At present, notes are issued by the foreign and Chinese banks only in the local currency of the places in which they are situated, the issues being restricted by their own regulations. These notes, which are in dollars, are redeemed by the banks at their face value; but a note for, say, 5 dollars issued by a bank at Shanghai is slightly discounted by the branch of the bank at Tientsin, Hankow, or any other city when presented for redemption.—*From Special Agents Series, No. 107, of U. S. Department of Commerce, "Cotton in China."*

## Unnoticed Pollution of the Air

IN an investigation of air pollution Mr. William Thomson, F.R.S. (Edin.) devised an instrument for detecting the very fine and invisible solids that pervade the atmosphere in every city. The air is drawn by suction through a hole ½ millimeter by ¼ millimeter in an otherwise airtight, stationary brass drum, the drum being connected with a vacuum pump. The air thus filtered leaves on the surface of a ribbon of filter paper over the hole the impalpable smoke and dust contained in it, the ribbon being drawn forward half an inch each half hour to obtain a new impression. This pollution is of so impalpable a character that it permeates all rooms in the city, and does not, of course, include smuts or heavier dust and fine ash which are constantly being discharged from factory chimneys.

# The Importance of Geographical Research—II*

## And a Plea for More Accurate Methods

By Major H. G. Lyons, D.Sc.

Concluded from Scientific American Supplement No. 2096, Page 47, March 4, 1914

The teaching of Prof. Davis in pressing for the employment of systematic methods in describing the landscapes with which the geographer has to deal has brought about a more rational treatment, in which due recognition is given to the structure of the area, and the processes which have molded it, so that land forms are now for the most part described more or less adequately in terms which are familiar to all geographers and which convey definite associated ideas, in the light of which the particular description is adequately appreciated. It has been urged by some that such technical terms are unnecessary and serve to render the writings in which they occur intelligible only to the few; that anyone should be able to express his meaning in words and sentences which will convey his meaning to all. There is no great difficulty in doing this, but in such descriptions to convey all that a technically-worded account can give to those who understand its terms would be long and involved on account of the numerous related facts which would be included. It is consequently essential in all accurate work that certain terms should have very definite and restricted meanings, and such technical terms, when suitably chosen, are not only convenient in that they avoid circumlocution, but when used in the accepted sense at once suggest to the mind a whole series of related and dependent conditions which are always associated with it.

The crystallization of such geographical terms into true technical terms is an important step in the furtherance of scientific geography, but it must be done by the geographers themselves, and no means of doing this is more fruitful than the work of original research and investigation in definite areas or on specific problems.

If we now consider some of the problems of human geography we shall find the need for such systematic study to be even greater; for the variable factors involved are more numerous than in physical geography, and many of them are difficult to reduce to precise statement; the quantitative study of the subject is, therefore, much more difficult than the qualitative or descriptive, so that the latter is too frequently adopted to the exclusion of the former. The remedy lies, I believe, in individual research into special cases and special areas where the factors involved are not too numerous, where some of them, at least, can be defined with some accuracy, and where, consequently, deductions can be drawn with some precision and with an accuracy which gives grounds for confidence in the result. The settlements of man, his occupations, his movements in their geographical relations are manifested everywhere, and subjects of study are to be found without difficulty, but their investigation must be based on actual observation, and on data which have been carefully collected and critically examined, so that the subject may be treated as completely as possible, and in such a way that the evidence is laid before the reader in order that he may form his own conclusions.

It is probable that some of the lack of precision which is to be found in this part of the subject is to be attributed to the want of precision in its terminology. For many things in human geography good technical terms are required, but these must be selected by those who have studied the type of phenomenon concerned and have a clear idea of the particular conditions which they desire to associate with the term; this is not the work of a committee of selection, but must grow out of the needs of the individual workers.

There is, it must be admitted, no small difficulty in using the same preciseness of method in this portion of the subject as is readily attainable in mathematical geography, and is usually practicable in physiography; but, at any rate, it is undesirable to indicate any condition as the controlling one until all other possible influences have been carefully examined, and have been shown to have less weight than that one which has been selected.

Whether the investigation deals with the settlements of man or his movements and means of communication, it is important that in the first instance problems of a manageable size should be undertaken and thoroughly treated, leaving larger areas and wider generalizations until a sufficient stock of thoroughly trustworthy material, which is in the form in which it can properly be used for wider aims, is available.

The relation of geographical conditions to small settlements can be satisfactorily worked out if sufficient trouble is taken and all possible sources of information, both of present date and of periods which have passed away, are utilized. Such studies are of a real value and pave the way to more elaborate studies, but we need more serious study of these simpler cases both to set our facts in order and to provide a methodical classification of the conditions which prevail in this part of the subject. Out of such studies there will grow such a series of terms with well-defined associations as will give a real precision to the subject which it seems at the present time to lack.

The same benefit is to be anticipated from detailed work in relation to man's communications and the interchange of commodities in all their varied relations. Generalized and descriptive accounts are readily to be found, and these are for the most part supported by tables of statistics, all of which have their value and present truths of great importance in geography, but the spirit of active research which aims at clearing up thoroughly a small portion of the wide field of geographical activities has unequaled opportunities in the somewhat shadowy relations between the phenomena which we meet in this part of the subject, for focusing the facts better, and obtaining a more exact view of the questions involved.

Where the geography of States (political geography) is concerned the same need for original investigation as a basis for generalizations may be seen. At the present time there is much said about the various boundaries of States, and in general terms the advantages and disadvantages of different boundaries under varied conditions can be stated with fair approximation to accuracy. But, I do not know of many detailed examinations of these boundaries or portions of them where full information of all the factors involved can be found set out in an orderly and authoritative manner, thus forming a sure foundation for the generalized description and providing the means of verifying its correctness or revising it where necessary.

Perhaps there is really more scientific research in geography being undertaken by individuals than I have given credit for, but certainly in geographical periodicals, and in the bibliographies which are published annually, the amount shown is not large; neither is the number of authors as large as might be expected from the importance and interest of the subject and from the activity of those centers where geography is seriously taught. There seems to be no reason why individual research on true scientific lines should not be as active in geography as it is in geology, botany, zoology, or any other branch of knowledge; and, just as in these, the real advance in the subject is dependent on such investigations rather than on travels and explorations in little-known lands, unless these, too, are carried out scientifically and by thoroughly trained observers who know the problems which there await solution, and can read the evidence which lies before them on their route.

If research in these directions is being actively prosecuted, but the appearance of its results is delayed, let us seek out the retarding causes, if there be any, and increase any facilities that may be desirable to assist individual efforts.

Short technical papers of a thoroughly scientific character, such as are the outcome of serious individual research, are, of course, not suitable for those meetings of geographical societies where the majority of the fellows present are not scientific geographers, but should be presented to small meetings of other workers in the same or allied fields, where they can be completely criticised. The reading, discussion, and the publication of papers of this class are for geography a great desideratum, for it is in them and by them that all real advance in the subject is made, rather than by tales of travel, however interesting, if these are not the work of one trained in the subject, having a knowledge of what he should observe, and of what his predecessors have done in the same field. The regional aspect of geography in the hands of its best exponents has given to young geographers a wide and comprehensive outlook on the interaction of the various geographical factors in a region, the responses between the earth's surface and the life upon it, and the control that one factor may exercise upon another. In this form the fascination of geographical study is apparent to everyone, but I sometimes wonder whether the exposition of such a regional study by one who is thoroughly master of the component factors, having a first-hand knowledge of all the material involved, and knowing exactly the trustworthiness of each portion, impresses sufficiently upon the student the necessity of personal research into the details of some problem or phenomenon in such a way as to gain a real working acquaintance with them; or does it, on the other hand, tend to encourage generalizations based on descriptive accounts which have not been verified, and where coincidences and similarities may be accepted without further inquiry as evidence of a causal connection which may not really exist? I imagine that the student may be attracted by the apparent simplicity of a masterly account of the geographical contents and responses involved, and may fail to realize that geographical descriptions, even though technically phrased, are not the equivalent of original quantitative investigation, either for his own education or as a contribution to the subject.

For these reasons I believe that societies can do far more good in the promotion of geography as a science by assisting competent investigators, by the loan of books and instruments, and by giving facilities for the discussion and publication of technical papers, than by undertaking the investigation of problems themselves.

Among the earlier presidential addresses of this section some have laid stress on the importance of the recognition by the State of geography in education; others have represented the great part which the geographical societies have played in supporting and advancing the subject; others again have urged the fuller recognition of geography by educational institutions. I would on this occasion attach especial importance to the prosecution of serious research by individuals in any branch of the subject that is accessible to them, to the discussion of the results of such work by others of like interests, and to the publication of such studies as having a real value in promoting the advancement of scientific geography.

* President's address before the Geographic Section of the British Association. Slightly abridged by the author in *Nature*.

### Finishing Wood Surfaces

A process has been patented by two inventors of Nottingham, England, for finishing the varnished or painted surfaces of wood boards and veneers, cardboard, paper and other materials, to produce a perfectly smooth and highly polished surface, superior to that ordinarily obtained with either varnish or paint. The surface of a piece of any of these materials is first given one or more coats of spirit varnish (resin dissolved in spirit) or paint composed of coloring matter mixed with vegetable oils, and as soon as the coating is dry, it is placed in contact with the polished face of a metal finishing plate; heat and pressure is applied for a short period of time, and then the material and plate are thoroughly cooled before separating them. The action of the heat and pressure causes the surface of the finishing plate to make perfect contact, so that the polished face is transmitted to the coated face of the material, while the cooling process before removal causes the coating material to become thoroughly set, and renders the finish obtained permanent. The process described is most conveniently carried on in a press heated by steam, fitted for changing cold water for the steam, so that the process of cooling the press and its contents can be rapidly effected. The finishing plates are preferably made of bronze or nickel with highly polished faces, and if desired they may be plated to prevent corrosion. The materials may be treated in wads; that is to say, a series may be superimposed and placed in the press with the finishing plates introduced between the layers of material. The process with cardboard and paper is well known, and wood boards and veneers have been treated in this manner after coating with solutions of acetyl-cellulose, collodion or celluloid, but not with ordinary spirit varnish or paint. It is therefore rather a slender basis for a patent—merely the application of a known process with materials in common use for the same kind of work. No difference in the process or appliances is explained.—*The Practical Engineer.*

### A Simple Dressing for Wounds

The extended hospital practice of several surgeons has shown that a simple dressing of castor oil is most excellent for abrasions, bruises and contusions, and for incised and lacerated wounds and burns and scalds. The part is first thoroughly washed with a warm antiseptic lotion, and then an oil soaked piece of lint, or a pad of sterile gauze, is applied directly to the injury. Over this is placed a piece of rubber tissue, or of paraffine paper, and the whole wrapped with an ordinary bandage. Healing generally follows by first intention, and there is hardly ever any suppuration.

# The Calorimeter as the Interpreter of the Life Processes*

## A Study of the Fuel Requirments of the Humane Individual

SHORTLY after the outbreak of the present war a scientific commission in Berlin reported that the quantity of energy units required during a year by 68,000,000 inhabitants in Germany amounted to about fifty-seven thousand million calories, and that under changed conditions of dietary habits eighty-one thousand million calories would be available. In accordance with the requirements of the crisis the habits of the people were changed.

Our own Commission for Relief in Belgium forwarded food on the basis of the knowledge that 1,000 calories in cornmeal cost 11 mills, in wheat 14 mills, in rice 18 mills, in wheat flour 20 mills, in beans 29 mills, and in pork "fat backs" 28 mills.

All this was the world's recognition of the need of fuel for the life processes in human beings.

Rubner's work has made it possible to picture the energy liberated in various forms of living things. Thus Rubner estimates that a horse requires 11 calories per kilogramme per day in order to maintain the normal life processes and for the fulfillment of the same necessities a man requires 30 calories per kilogramme of body weight, a new-born mouse weighing one gramme requires 654 calories per kilogramme while a yeast cell weighing 0.000,000,000,5 gramme produces 1,743 calories per kilogramme of substance, this also being the heat produced by a kilogramme of diphtheria bacilli. The energy production in these lower forms of life was measured by determining the rise in temperature of the medium in which they lived when this was confined within the limits of a Dewar flask. The heat production of a kilogramme of yeast thus measured was three fold that found for the same unit of mass in a new-born mouse, 58 times that of a man and 157 times that of a horse.

Although these values appear to be extremely variable, there is one unit of measurement which in mammalia is quite constant and that is the heat production per square meter of surface. Bergmann, in 1848, was the first to advance this hypothesis and a year later the French observers Regnault and Rieset stated that the heat production of sparrows per unit of weight was ten fold that of fowls, a phenomenon which they asserted was due to the fact that the smaller animals present a relatively larger surface to the surrounding air and thereby experience a considerable chilling, with the consequent generation of sufficient heat to maintain the normal body temperature. In 1883, Rubner published calculations which showed that the heat production of mammalia of various shapes and sizes was the same per square meter of surface. Figures are given such as 1,042 calories for man, 1,039 for the dog and 1,122 calories for the newborn mouse per square meter of surface during periods of 24 hours when the temperature of the environment is 15 deg. Cent. and when moderate movements are permitted.

Further analysis showed Rubner that this evenness of heat production per unit of body surface was not due to any relation between the area of body surface and the area of cell surface within the organism. There are in one kilogramme of body weight of man 150.2 square meters of such surface and each square meter of cell surface produces 0.2 calorie per day. In the new-born mouse each square meter of cell surface produces eleven times this amount or 2.2 calories. It is of interest, also, to note that a kilogramme of yeast cells presents a surface area of 600 square meters and at a temperature of 38 degrees, or that at which mammalian cells exist, 1.25 calories per square meter of surface are produced in 24 hours, 8.34 grammes of cane sugar undergoing inversion and fermentation during that interval. This reaction is independent of the strength of the sugar solution within the wide limits of 2.5 to 20 per cent. If the strength of the solution be at the maximum of normal reaction, or 20 per cent, the quantity of sugar utilized in 24 hours would be contained in a film 4/100 of a millimeter in thickness surrounding the cells. A like analysis shows that in man whose cells are bathed in a medium containing 0.1 per cent of sugar the quantity necessary for the support of life during one day would be contained in a layer which, if spread around the cell, would be 5/100 of a millimeter in thickness.

From the calculation of the energy requirement in the food for life of a nation to the energy liberated by a yeast cell in its simple resolution of sugar into alcohol and carbon dioxide is indeed a far cry, except as showing that the energy doctrine, as enunciated by Rubner, unites the world of living things.

In 1912 I calculated that the heat production of three quiet and sleeping dogs was 759, 748 and 746 calories per square meter of surface at an environment temperature of 26 degrees, that a dwarf produced 775 calories per square meter of surface, and that four out of five sleeping men investigated by Benedict showed an average heat production of 789 calories per unit of area. Only in the infant 7 months old investigated by Howland, did the metabolism appear out of the ordinary and reached a level of 1,100 calories, and this factor was specifically pointed out as indicating a higher metabolism in the youthful protoplasm than is present in the adult.

When the Russell Sage Institute of Pathology constructed in Bellevue Hospital an Atwater-Rosa calorimeter copied in the main after the successful models of Benedict, it became absolutely essential that some criterion of normal metabolism be established, as a basis from which one could estimate whether the metabolism of a patient under investigation was higher or lower than the normal. The severe criticisms of Benedict upon the method of estimating heat production from the unit surface led to a very careful review of all the evidence and to new experiments. Du Bois, who took up this work, has used an accurate and ingenious method with which he has been able to actually measure the surface area of normal men. He and Mr. Delafield Du Bois have discovered that the formula heretofore used for estimating the surface area in man showed an average inaccuracy of 16 per cent and a maximal variation from the normal of 36 per cent, this being found in very fat individuals. A new formula has been evolved which gives an average variation of ±1.5 per cent and a maximal variation of ±5 per cent. Using the older formula of Meeh, the heat production per square meter of surface is 833 calories during 24 hours, but using the more accurate formula of Du Bois that rises 16 per cent to 953 calories. In normal adults of various shapes and sizes this is the *basal metabolism* as measured when the individual is resting and before the administration of food in the morning. The variation from this standard does not exceed 10 per cent in 90 per cent of the cases. The maximal variation is 15 per cent.

The critical studies of F. G. Benedict have been especially helpful in stimulating the reconsideration of all the data and methods in relation to this subject. Benedict is in agreement with Carl Voit when he concludes that the mass of active protoplasmic tissue determines the height of the metabolism. However, in the search for a standard upon which to calculate what would be the normal heat production of a man suffering from disease it is obviously impossible to measure the mass of active protoplasmic tissue. It is, therefore, most fortunate that the unit of surface area eliminates the same amount of heat in the normal adult within 10 per cent of a determined average.

The reason for this is not clear, but the fact is established. It is known that a regulating mechanism maintains the body temperature at a fixed point, though the reason for this is also undetermined.

The figures given hold true for the adult but are subject to variations due to age.

Murlin has pointed out that the new new-born baby has a distinctly lower metabolism than normal and that this rapidly rises during the first year to a standard above the normal. It should be remembered in the first place, that the newly born may be considered in the light of an internal organ which has been protected from external stimuli. This is indicated by the work of Murlin upon the pregnant dog and from that of Murlin and Carpenter upon the human mother. The increase in heat production during the first months of the infant's life may be due to the union of the muscles with medullated nerve fibers. Furthermore, one finds on analysis that there is 24 per cent of muscle tissue in the newly born baby as against 42 per cent or nearly double that quantity in the adult. These proportions are reversed as regards glandular tissue, there being 47 per cent of this tissue in the new-born and only 24 per cent in the adult. It is this preponderance of glandular tissue in early life that may be the cause of the prevalence of the higher metabolism during the early period of growth. Du Bois has found that in a number of boys just before puberty the heat production is 25 per cent above the normal and it is interesting to query whether this be due to glandular activity.

With the approach of old age the metabolism falls about 10 per cent; there is no longer quite the same intensity of oxidation as at the height of a man's virility.

In conditions of disease, as in those of health, the same materials, such as protein, fat and carbohydrate, are oxidized and in the normal fashion, and they produce heat after the normal manner. The disease of diabetes presents a striking exception, as sugar may here remain unoxidized. In general, one may say that the intensity of the metabolism processes are little affected in many diseased conditions. In diabetes the heat production does not rise appreciably above the normal. The calorimeter in the hands of Du Bois and his fellow worker has shown that in severe anemias and in heart disease involving dyspnea, the heat production may increase. This is very probably due to the stimulus of lactic acid, a similar phenomenon being witnessed in a dog poisoned with phosphorus. In a typical fever such as typhoid the heat production may increase between 40 to 50 per cent, and in severe cases of exophthalmic goiter it rises to between 75 to 100 per cent above the normal. It is fortunate that the ingestion of food which in the normal individual causes an increase in heat production, does not abnormally stimulate the fires of metabolism in these patients already suffering from intensified oxidation processes.

The inner process of heat production involves the interplay between the living cells of the body and the nutrient constituents of the fluids which bathe them. It has been known since the time of Lavoisier that the ingestion of food results in an increase in metabolism. In the presence of abundant food the cells produce heat in increasing measure. Thus, after giving meat alone in large quantity to a quietly resting dog the heat production may be double that of the normal basal metabolism. The constituent amino-acids of protein are relieved of their $NH_2$ groups and the denitrogenized remainders are utilized for heat production, any excess being converted into glucose and retained in the organism as glycogen. The great rise in heat production is in large measure due to the direct chemical stimulation of the cells through the metabolism products of certain amino-acids. The proof of this lies in the fact that if glycocoll or alanine be given to the diabetic dog the heat production is largely increased, although these substances are not oxidized and there is, therefore, no evolution of heat from them, for they are converted into glucose and urea which appear in the urine. When the same method is applied to the study of the sugars, it fails to support the idea that the intermediary products of sugar metabolism directly stimulate the cells to a higher heat production. Thus, fructose administered to a diabetic dog caused no increase in heat production, although it underwent chemical change, for it was found as glucose in the urine. Since all the evidence regarding this reaction points to a preliminary cleavage of fructose which contains six carbon atoms into two molecules each containing three atoms of carbon and to the subsequent synthesis of these molecules into glucose, one may reason that the preliminary cleavage products of carbohydrate metabolism are not direct stimuli to protoplasm, as are those of amino-acids like glycocoll and alanine, but that normally the mere presence of a large number of metabolites of sugar results in their oxidation in increased measure.

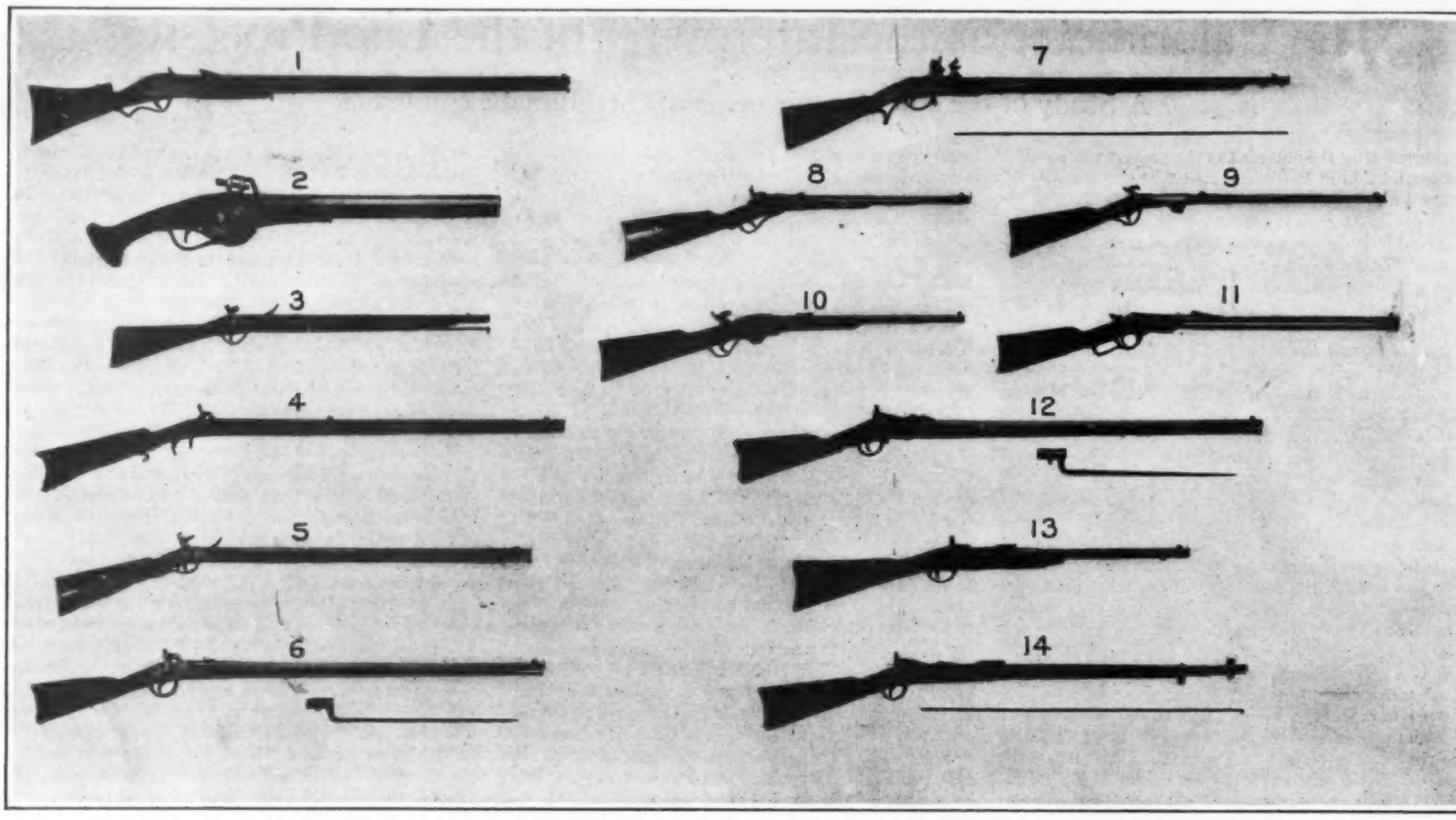
Rubner has shown that when the yeast cell is bathed in a solution of sugar and peptone the protein is used for growth or cell repair only, while alcoholic fermentation furnishes the energy, and as before stated the quantity of this energy is independent of the strength of the solution. So also in a mammal such as the dog, if one give 50, 70 or 100 grammes of glucose, the energy production increases in all cases to a level of about 30 per cent above the normal. It appears that the cells by a process called "self-regulation" use the fragments of broken glucose up to a certain limit which is not transcended. Any excess of these fragments is converted into glycogen or into fat, a small quantity of energy being absorbed in the first process and a small quantity being liberated in the second. The result of this is that beyond a certain limit of carbohydrate plethora, the heat production in the dog scarcely rises, and this is analogous to the behavior of the yeast cell toward its nutritive environment.

The study of the intermediary metabolism upon which the total heat production of an animal is based, furnishes a fascinating field for the scientist, and it is also evident that the study of the fuel requirement of the human individual in health and in disease presents many problems of importance for the general welfare of the community.

* Read at the New York meeting of the National Academy of Sciences. By Graham Lusk.

### Extinguishing Burning Liquids

MANY people cannot understand why it is permissible to use water for extinguishing some burning liquids, and not for others. For instance, water is effective for extinguishing burning alcohol or acetone, but quite the reverse in the case of gasoline or oil. The difference lies in the fact that water mixes readily with the first two liquids, while gasoline and oil do not mix with water, but float upon its surface, and are thus scattered over a large area. However, the application of a very large quantity of water to a small quantity of burning oil may aid in extinguishing the fire by its cooling influence.




1, Old matchblock arquebuse. 2, Pistol showing wheel lock. 3, Flintlock musketoon. 4, American or squirrel rifle. 5, American flintlock army rifle of 1815. 6, Springfield rifle, 1863. 7, Breech loading American army musket, 1824 8, Sharp breech loading carbine, 1852. 9, The Burnside carbine, a Civil War weapon. 10, Spencer repeating breech loading gun of 1860. 11, Henry magazine breech loading musket, 1860. 12, The Allin alteration Springfield rifle, 1865. 13, The English Snider alteration. 14, Springfield rifle, 1873.

# The Development of Military Small Arms

## A Brief Review of the History of Portable Fire Arms

By Colonel Orin B. Mitcham, Ordnance Department, U. S. A.

WEAPONS that would maim or kill at a distance have been known from the earliest times; they must have been possessed even by men in prehistoric ages. When it is considered that the Australian aborigine has made use of the boomerang and the throwing stick for throwing spears, there can be but little doubt that others no higher in the stage of civilization had developed means to the same end. Naturally the first weapons would have been the stick and the stone, leading then to the sling, the bow and the javelin. There is little doubt that gunpowder was known in the Far East, that is, in China and India, centuries before it was introduced as a propellant in Europe.

The first portable fire arms in use in Europe were probably invented about the middle of the fourteenth century, and consisted simply of tubes of iron or copper fired with supports. They were loaded with lead or iron balls, and fired by means of a lighted match held in the hand. The services of two or more men were required to manipulate them, and as their rate of firing was relatively slow when compared with the use of the bow, it was a long time before they became the principal arm for the foot soldier.

The first definite fact regarding the use of fire arms was at the battle of Crecy in 1346, where it is stated that the English made use of them. At that time it was probable that some form of matchlock was used. Fig. 1 shows one of a later period, but illustrates the essential principles. It is an arquebuse, having a stock to go against the shoulder, and to bring the breech to the eye. It will be noticed that the arm is exceedingly heavy, so that it was probably supported at the muzzle by a crutch of wood or iron, while it was aimed from the shoulder. The peculiarity of this matchlock is that there are sights front and rear, something not generally found on such guns. As it will be seen from its name, the gun was fired by pulling upon the trigger. This threw the lighted match or lighted material held in the projecting arm into the pan that contained the priming charge. Flame was carried from the touch hole into the interior of the barrel, and the piece was discharged. Of course no very great accuracy could be expected from any such weapon.

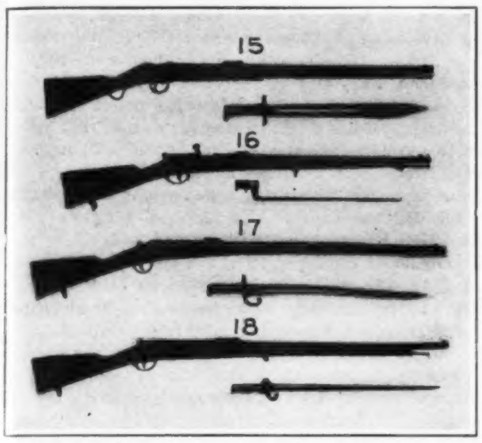
The next advance was the wheel lock, which consisted generally of a wheel rapidly revolved by means of a spring. This wheel was set in motion by the spring by pulling upon the trigger, the wheel struck a piece of iron and antimony placed near the priming charge, which was set on fire by sparks after the manner of the flintlock. The construction is well illustrated by the view of the pistol in Fig. 2.

The flintlock was derived from the wheel lock by substituting flint and a steel battery for the wheel. This was introduced in the French Army, as far as can be learned, in 1680, and continued in military use in all armies almost uninterruptedly until 1842, when it was replaced in practically all instances by the well known percussion lock, firing a percussion cap. The example of the flint lock in Fig. 3 is a musketoon, but of the Brown Bess pattern. This gun received its name from having been adopted during the reign of Queen Elizabeth, when all of its parts (barrel and fittings) were browned, hence its name. Since this gun is a smooth bore, the ball to be loaded into it must be smaller than the bore. As a consequence, when it was fired, there was considerable balloting of the projectile, which led to great inaccuracy after it left the muzzle. Owing to this inaccuracy these guns were often fired from the hip, and in military service their effect was obtained in general by volley firing at ranges not exceeding 100 yards.

It is not generally known or realized that the development of small arms was remarkably rapid and thorough in our own country from the time of its settlement to the present day. This development was especially true in the early stages of the settlement of the United States, in view of the fact that the settler depended upon his gun not only largely to supply himself with game for food, but also as a protection for himself and his family from hostile Indians. These facts led to the use of the rifle more largely in America than in any other country, and at much earlier dates. The general principle of rifling had long been known and was used in Europe, the first grooves being straight. At a later time the superior accuracy of the spiral groove was discovered, very probably by accident. The rifle firing spherical balls began to be used as a military weapon, but the difficulty of loading, ordinarily by means of forcing the ball down by blows on the ramrod, made it very slow and exceedingly difficult, especially so after a few rounds had been fired. All of these points led to the general manufacture and use in our country of what may be termed the "American" or "squirrel" rifle, illustrated in Fig. 4. This rifle was of relatively small bore in order that as many charges as possible could be carried. It was made heavy in weight in order that the vibration of the barrel should be relatively small. It was generally made long, and a fine gunpowder was used in order that the effect of the explosive charge through the bore of the rifle should be as long as practicable.

It may be said that the typical American flintlock rifle was one of the leading factors in determining the history of our country. Of necessity many of the early settlers became remarkable marksmen with this weapon, and its use was greatly added to by the discovery of the greased patch. This consisted of a piece of greased cloth that was placed over the muzzle of the gun, and when the bullet was inserted, entirely enveloped it. Such an arrangement facilitated the ramming home of the ball. When the piece was fired this greased patch was carried around the rifling, but flew off as the ball entered the air on its way to its target. It is hard to realize the possibilities of this gun when in the hands of many of the older settlers. As a military weapon it was used by the Provincials in the British forces at the siege of Louisburg in 1745, where it was stated that the accuracy of their fire against the French gunners in the fortress was so great that they practically compelled the surrender of the works. It was a well known fact that Washington's Provincials saved all that were left of the British forces after the massacre at Fort Duquense. Later, at the siege of Quebec, Gen. Wolfe is stated to have placed in front of his army the Provincial Pennsylvanians, being led to this either by believing them untrustworthy or by having great confidence in the accuracy of their rifles. It is stated that their fire compelled the French to flee and the battle was won.

During the Revolution it was found that the mortality among the British and American troops from gun fire was in the ratio of five British to three Americans. This ratio was undoubtedly due to the accuracy of the American riflemen in handling their weapons. It is stated that Lord Howe, having sent reports to England of the remarkable effects of the rifle fired in the hands of American troops, finally captured a sharpshooter and sent him to England with his entire outfit. There his shooting was so remarkable as to surprise the entire country. It is said to have led to one result not expected by Lord Howe, that is, it stopped recruiting




15, English, Martini-Henry rifle. 16, Prussian needle gun. 17, French Chassepot. 18, French Lebel rifle of 1893.

absolutely, and caused the enlistment of the Hessians and other troops that were later sent to the United States. It is a matter of history that Gen. Daniel Morgan's corps of riflemen, most of whom were Virginians, gained the battle of Stillwater and led to the final surrender at Saratoga. Morgan was in many respects a remarkable man, though one without education. The statement has been made that at the time of his greatest reputation Frederick the Great spoke of him as the greatest leader of light infantry in the world.

Military rifles were manufactured in this country as early as 1804 at the Harpers Ferry Armory, but the most of our infantry were armed with smooth bore muskets until about 1855. The flintlock shown in Fig. 5 is a rifle made at Harpers Ferry, muzzle loading, in 1816; it will be noticed that it has a patch box in the butt. This is the first rifle of which the caliber is determined, and is of the model of 1815. By this time the use of the greased patch had found its way into military circles.

The highest example of muzzle loading gun will be seen in the United States Springfield rifle model of 1863, illustrated in Fig. 6. It will be noticed that it was a percussion type, and it was with weapons of this type that the War of the Rebellion was largely fought. In the early years of that war, it is believed that even many flintlock guns and American rifles were used on both sides, Union and Confederate, especially in remote districts.

BREECH LOADING SMALL ARMS.

While changes and improvements were being made in muzzle loading guns, another most important development was in progress, which need only be outlined here. The convenience of putting in the charge at the breech and not at the muzzle end of the gun had long been recognized, and cannon had been so constructed. Much ingenuity was shown in the early attempts to apply the breech loading principle to fire arms, but due to improvements in gunpowder and the desire to give the projectile as high a velocity as possible, the simplicity and strength of the muzzle loaders were indispensable. Examples of breech loading fire arms, as far back as the sixteenth century, can be found in many museums, and no doubt the attempt to perfect a breech loading fire arm was never abandoned for a very long time. During the Revolution a breech loader invented by Lt. Col. Patrick Ferguson, Seventy-first Highlanders, had some success. The breech was closed by a screw opening from below across the rear of the barrel, and worked by the trigger guard as a lever. Examples of this gun are now very rare. But the difficulties of dealing with the escape of gas through the joints of the breech action, and also by the deposit that was left when the gun was fired, were so great that it was a long time before any nation adopted for military use a breech loading system.

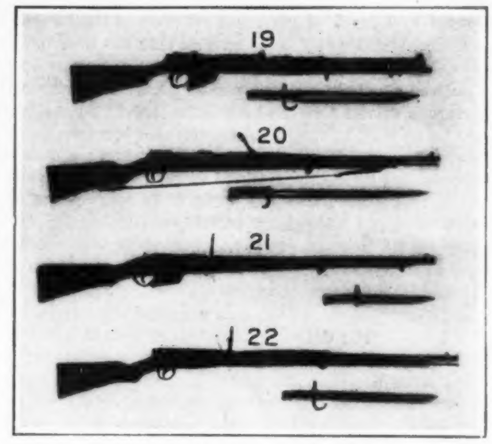
There is one exception shown in Fig. 7 and believed to be the first breech loader made as a military small arm in a national armory and regularly issued to troops. This is the Hall breech loading musket of the United States service, caliber 0.54, and of the model of 1824. The inventor of this rifle, Hall, was a man many years ahead of his time. He was the first to urge the interchangeability of the parts of military rifles. It is claimed that his patent for a breech loading arm was granted May 21st, 1811, covering both smooth bore and rifled arms. Under this patent there were manufactured at different times muskets, rifles and carbines, both flint and percussion. In 1824 and 1826, 2,000 of these flintlock rifles, caliber 0.54, were made at the Harpers Ferry Armory, and issued to troops for systematic trial. The design gave so much satisfaction that up to May, 1842, 37,000 rifles and carbines had been made in the national and private armories. None, however, were made after 1844. It will be noted that the breech block or chamber was hinged at the rear and lifted at the front. The charge having been inserted, the block was closed, and the piece fired in the ordinary manner. No doubt the deposit in firing, combined with dust, dirt, etc., that would necessarily be accumulated from service in the field, gave much trouble in procuring proper obturation. At the same time it must have been in its way a relatively satisfactory gun, otherwise it would not have remained in the service as long as it did. It will be noted that this gun is provided with a rod bayonet, a feature later of some of the models of the Springfield rifles, single loaders, and finally intended to be issued with the army magazine rifle, model of 1903, but for which the present knife bayonet was substituted.

Possibly the next best example of a breech loading arm of about this time is shown in the Sharp's carbine, model of 1852, given in Fig. 8. It will be noted that the breech of the carbine is closed by a block sliding vertically across the rear of the barrel operated by a lever from below, and that a percussion cap was used for firing. Particular attention is called to the edge of the block, which is sharp: this is intended to cut off the rear of the paper or linen cartridge used with this model of gun. Types of this gun were used in the army as early as 1846 in the Mexican war. The gun was actually patented in 1848, and was thoroughly tested by a board of officers, who decided that it should be the principal arm for mounted troops. It held its place among the great number of carbines and rifles issued during the Civil War until the introduction of the Springfield breech loading carbine.

The Burnside carbine shown in Fig. 9, also largely used during the civil war, has, as will be noted, a movable chamber that is pivoted in front under the barrel and operated by a side lever. This carbine used an unprimed metallic cartridge, the front part of the shell covering the joint between the breech block and the barrel to prevent the leakage of gas. The cartridge used with this was a single fire metallic case with a perforation in the center of the base. This perforation admitted the flame from the cap that was placed on the outside nipple. In closing, the block has a forward movement, so that the bullet dropping from the forward end of the chamber was pushed into the rear of the barrel. This arrangement was fairly satisfactory; a number of the guns were used at one time in the United States Army.

Next in order, however, to the Sharp carbine in use during the civil war was the Spencer repeating breech loading gun, caliber 0.52, given in Fig. 10. This gun was introduced in 1860, and was the earliest magazine gun used in actual war. The lever underneath swinging down and forward draws down the breech block and swings it backward far enough for a cartridge to slip over the block from the magazine in the rear, a finger over the mouth of the magazine preventing the cartridge from falling out. Swinging the lever backward pushes the cartridge in and closes the breech. The tube containing the spiral spring of the magazine in the butt of the gun can be drawn out from the rear to allow the cartridges to be dropped into the magazine. As soon as the tube is returned to place, the pressure from the spring forces the cartridges forward. The spring has a head or follower to bear upon the head of the cartridge, and this is common to all spring magazines. Since a rim fire cartridge was used with this gun one of the principal objections to it was that the shock of discharge led at times to the explosion of the cartridges in the magazine, blowing off the butt.

Another gun representing the type of a magazine under the barrel is the Henry magazine breech loading musket, Fig. 11, Model of 1860, which was also used by some troops during the War of the Rebellion. It is operated by a lever swinging forward from below, as will be seen. This, acting on an elbow joint, works back and forth; an arm connected with the lever causes the carrier block to slide up and down, transferring the cartridges from the level of the magazine to that of the barrel when the bolt is back, and dropping the block when the bolt is forward and the cartridge pushed into




19, English Lee-Enfield, 1903. 20, Late model of German Mauser. 21, Austrian Mannlicher. 22, Latest Mauser model, used by Japan.

the chamber. The magazine is loaded from the front, the tube being in two sections, the muzzle part being made to swing around to the side to clear the mouth of the magazine tube. Having pushed the spring up by means of the thumbpiece into the muzzle part, the cartridges can be dropped in the tube. This gun later developed into the form of the Winchester.

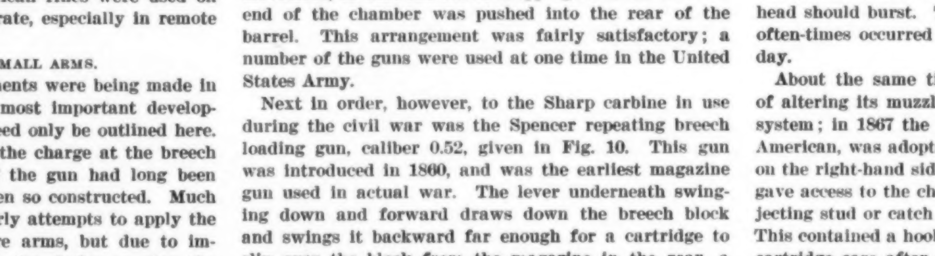
In 1865 a design for changing the United States rifle musket, caliber 0.58, model of 1855, into a breech loader was proposed at the Springfield Armory. This was known as the Allin alteration, Fig. 12, and consisted in reducing the caliber to five tenths of an inch by inserting an iron or steel tube into the barrel and adding a breech block hinged to the barrel on the upper side, which was cut away to receive the block. Five thousand of these guns were made as soon as the civil war terminated, permitting the attention of the Ordnance Department to be directed from the question of the immediate supply of the most easily manufactured arms. This Allin gun is the first of the series of alterations of the muzzle loading rifle musket that developed into the Springfield Rifle, caliber 0.45, so long used by our Army before the introduction of the small bore rifle. An objection to the arrangement of the Allin pattern was that the cut for the extractor on the side rendered the stock liable to be blown away in case the cartridge head should burst. This bursting of the cartridge head often-times occurred with the rim fire cartridge of that day.

About the same time England took up the question of altering its muzzle loading guns to a breech loading system; in 1867 the Snider system, the invention of an American, was adopted (Fig. 13). The block was hinged on the right-hand side of the barrel, and on being opened gave access to the chamber in the breech end. The projecting stud or catch on the side held the block in place. This contained a hook extractor that withdrew the empty cartridge case after firing. The type of cartridge used with this gun was in general the Boxer, a wrapped metal cartridge.

In connection with the Allin alteration various changes were made in the model until 1873, when a board of officers appointed in pursuance to an Act of Congress reported in favor of the Springfield system. This resulted in the Springfield rifle, carbine and cadet rifle, model of 1873 (Fig. 14). The gun is too well known to need description; it is thought the long service that it gave under all conditions in our Army showed it to be one of the best single shot rifles used in any army in its day. The rifle fired in general a bullet of 500 grains with 70 grains of black powder, and its maximum range was about two miles.

In England the adoption of the Snider or Enfield system was acknowledged to be only a temporary expedient, and every effort was made to procure a single shot breech loader that would be satisfactory for their service. After years of experiment the Martini-Henry rifle, Fig. 15, was adopted. The breech block was hinged at the rear, and was operated by a lever. This gun fired a bullet of 480 grains and gave so much satisfaction in the British service that after its caliber had been changed for use in firing a 380-grain bullet, it was continued in the service until superseded by the present magazine gun, the Lee-Enfield. It is understood that some of these guns may even now be in use in the trenches in France.

We now come to one of the most famous of the early breech loading guns, the Prussian needle gun, in-




23, 1902 and 1908 Krag-Jorgensen, used by the United States. 24, Latest American military rifle.

vented by Dreyse in 1838, and adopted in the Prussian service in 1841 (Fig. 16). In this rifle the breech was closed by a fitting, much in the form of a door bolt. Ignition was effected by a long needle contained in the bolt that was driven forward by a spiral spring on the trigger being pulled; this needle perforated the base of the cartridge and ignited the charge by striking a disk of fulminating material contained in the base of the paper sabot that surrounded the ball. This was one of the earliest of the self-primed cartridges adopted for military service, and the gun is the first example of the bolt system now so common in Europe and in this country. There was no gas check except that which resulted from the mechanical fit of the bolt over the conical end of the barrel. The defects of the breech action were considerable. After a few rounds the rifle could not be fired from the shoulder owing to the escape of flame. The needles rusted, broke, and gave much trouble. Yet the gain in rapidity in loading was more than enough to compensate for the defects, and this became the general arm of the German and Prussian troops in the wars of 1848, 1866 and 1870. It was later replaced by the single loader of the Mauser system, caliber 0.43. In view of the military success of the needle gun, the adoption of a breech loading system became of immediate importance to other nations. The French adopted the Chassepot in 1866 (Fig. 17). This was a rifle of 0.434 inch caliber with a bolt action somewhat similar to the needle gun in principle. The gas check was a rubber washer on the end of the bolt. This was compressed axially by the powder pressure and forced against the side of the chamber, being similar in principle to the De Bauge gas check now used in heavy guns. The cartridge was self-consuming and had a cap on the front which was ignited by the needle that passed through the cartridge. This needle, as it will be noted, was much better protected than in the Prussian needle gun. The French Gras rifle, model of 1874, was the development of the Chassepôt as adapted to the metallic cartridge.

### MAGAZINE GUNS.

All of above mentioned guns were large bore rifles, and their successors, the magazine guns of similar caliber using black powder ammunition, can be well passed over. The advantages to be gained by an increased rapidity of fire are too obvious to need discussion, and of course all nations strove to produce for military purposes magazine arms.

About 1880 experiments were being generally conducted to produce a rifle having greater range, but more especially a much flatter trajectory than the then existing type could give. In order to flatten the trajectory to produce a greater dangerous space, it was necessary to greatly increase the velocity and also to keep high what is known as the sectional density of the bullet, that is, the weight of the bullet in pounds divided by the area of cross-section of the bore across the grooves in inches; for the power of the bullet to overcome the resistance of air—that is, its ranging power—is proportional to this value. It was therefore necessary to reduce both the weight of the bullet and its diameter. It was found that the modern small caliber bullets required a quick twist of rifling for steady flight; but the lead bullets tried at first were driven out across the lands, not following the rifling. Maj. Rubin of the Swiss army first overcame this difficulty by using a lead core in a copper envelope. This envelope was strong enough to resist both the torsion and tension when fired, and caused the bullet to follow the rifling. This, or similar bullets, are now in universal use in nearly all military rifles.

The early experimental small bore rifles were used with black powder, generally in a compressed form; but, on account of the low velocities obtained, and the smoke and fouling, there was no great success with the new bullet.

In 1885, M. Vieille, a chemist in the French powder factories, invented a smokeless powder, and this was the leading factor in making the small bore rifle a success. Such powders give a higher velocity with lower pressures than black powder, and are practically smokeless, giving little or no residue in the barrel.

The French at once took advantage of this invention, and the Lebel rifle, pattern of 1886 modified in 1893, Fig. 18, was the result. It was the first small bore rifle to be adopted by any nation, and with it smokeless powder was first used. It has a tubular magazine under the barrel for eight carriages, and is of 8 millimeters (0.315 inch) caliber. The cartridges are inserted into the tube one at a time in the rear end through the body of the rifle. They lie in a line nose to base, and are pushed to the rear by a spiral spring and plunger. They are raised up in front of the bolt by a pivoted carrier operated by the bolt. The Lebel is an excellent type of the group of magazine small arms using tubular magazines.

The Lebel has been severely criticised for its generally crude and amateurish appearance. In view of the fact, however, that this pattern of rifle has been in use in the French army now for nearly thirty years, and has given satisfaction in campaigns in Madagascar, Tonquin, and especially in Algeria and Morocco, it is believed that such a criticism of the gun is an injustice. One criticism calls especial attention to the long triangular bayonet such as was discarded in our army twenty years ago. However much such a bayonet may be criticised, there is no doubt that the length of the bayonet added to that of the rifle has been found to be of great advantage in the hand to hand fighting in the trenches during the present European war. No doubt one reason why a more improved form of Lebel has not as yet been adopted by the French government is in view of the tremendous expense that would be entailed in making such a change in its armament, added to the possibility of the early adoption of some form of automatic shoulder rifle by all nations.

The rifle used in the English service is the short Lee-Enfield 7.7 millimeter (0.303 inch) pattern 1903 gun (Fig. 19). There was an older and longer gun of this type; it is understood that the earlier patterns have been issued to the Territorial and other troops during the present war. The barrel of this gun is only about 25 inches long, though a velocity of 2,400 foot-seconds is given to the ball by the new ammunition instead of the 2,000 feet per second of the older model. This rifle is provided with a box magazine under the barrel that is loaded by chargers containing five cartridges each. The box holds ten cartridges when the magazine is filled. This form of magazine is decidedly superior to a tube magazine, as it is simpler, and the balance of the arm is not altered as the magazine is emptied. The short barrel with bayonet is a decided disadvantage when compared with the French gun. The length of the former, including the bayonet, is approximately 72 inches, while that of the latter is only 62 inches. The difference of 10 inches is a decided advantage in bayonet fighting.

The type of gun most generally employed by nations throughout the world is the Mauser system; the gun shown in Fig. 20 is the latest pattern of the German Mauser, caliber 7.9 millimeters (0.311 inch) and from this type the new American Springfield was taken. The great advantage of the Mauser system is that in addition to the safety lug ordinarily employed, it has two locking lugs at the front of the bolt. Also, the sleeve, extractor, etc., are generally excellent parts as compared with other rifles. In its simple sight-seeing arrangement, finish, accuracy, and velocity given to its bullet, it has no superior, and in many cases, hardly an equal among the rifles of other nations. It will be noticed that it has a long sword bayonet carried in a scabbard at the soldier's belt. Its long barrel and bayonet have a length of 70 inches, which, it is thought, exceeds that of all other nations except the French Lebel.

Fig. 21 shows the latest pattern of the Austrian Mannlicher, caliber 0.8 millimeter (0.315 inch). It is among the class known as a straight pull bolt, or those that can be drawn back by pulling the bolt lever straight to the rear. The operation of the bolt in closing and opening is very similar to that of the ordinary automatic screwdriver. This type of rifle action is very fast, but it is said to be more tiring for a long series of shots, because of throwing the strain on one set of muscles only. It is a clip loader, each clip containing five cartridges, the clip being held at the back end of the magazine by a catch. As soon as the clip is empty it falls through to the ground, and another clip can be readily inserted. This gun is provided with a sword bayonet as shown.

In Fig. 22 will be seen what may be called the latest as well as one of the most original types of the Mauser system of rifle. It is the Japanese rifle, model of 1905, caliber 6.5 millimeters (0.265 inch). The Japanese have adopted from the Mauser all of its good points, and have really produced a very remarkable rifle. Attention is called to the manner in which the locking bolt can be applied, and the easy way in which the gun can be immediately made ready for firing. Its caliber is so small that it would seem that it should be almost ineffective. The bullet, however, is fired with a velocity of 2,900 feet per second.

Coming now to our own country, the gun in Fig. 23 is one very familiar and known as the United States Magazine rifle, model of 1892 and 1898, Krag-Jorgensen. It is really the original Swedish Krag-Jorgensen system modified and improved.

The magazine is a horizontal one of the fixed box type, located under and to the left side of the receiver and loaded by hand by opening the gate that is on its right side. It has a cutoff holding five cartridges in reserve, while it can be used as a single loader. It was adopted originally after severe tests of rifles representing the principal designs of European and American manufacture, and many minor changes were made in developing the latest model rifle. It was the one used by regulars and other troops during the Spanish-American war, and its serviceability as a military weapon was readily recognized. The defect in the gun was that it had a single locking lug at the front instead of two to withstand the pressure of the powder. When an attempt was made to increase this pressure and raise the velocity with the same weight of bullet, this single lug was cracked or broken off. It became evident that a new system must be undertaken.

This led to the adoption of our magazine rifle, model of 1903. The rifle in Fig. 24 shows the latest approved ideas as to the design and construction in the United States. It is a charger loading rifle provided with a cutoff.

Each clip contains five cartridges. It can be used as a single loader with magazine empty or with the contents of the magazine in reserve. It can also be used as a clip loading repeating rifle. It, therefore, possesses all the advantages of the reserve magazine and repeating systems. In view of recent developments in warfare in Europe, it has however the defect of having a relatively short reach; the length of the gun complete is only 43 inches, with a total length, including bayonet, of only 59 inches. The standard muzzle velocity is 2,700 feet per second for a bullet weighing 150 grains. Twenty-three aimed shots have been fired in one minute with the rifle used as a single loader, and twenty-five shots in the same time using magazine fire. Firing from the hip without aim, thirty shots have been fired in one minute with the rifle used as a single loader, and forty shots using magazine fire. The difficulty of supplying sufficient ammunition under such conditions is too apparent to need discussion. The maximum range of the gun is about 4,900 yards, and the chamber pressure about 51,000 pounds per square inch.

In the preceding remarks it has been the object simply to give an historical outline of the development of the military small arm to the present day. An examination of these rifles will show that the adoption and manufacture of any special type is a matter of a great deal of time, labor and expense. In the present magazine rifle used in the United States service, it is stated there are over one thousand different operations, for the parts are to be interchangeable in all guns, and an extensive system of gages, templates and other devices is employed. An inspection of each working part is made after every important operation. In the United States the limit as to the diameter of the bore and of the rifle grooves is one one-thousandth of an inch, and exact dimensions are required in the chamber. Only the best quality of steel can be used in any of the guns, especially in the barrel. The physical requirements of this last are now 75,000 pounds per square inch elastic limit, 110,000 pounds tensile strength, with an elongation of 20 per cent and a reduction of area of 45 per cent in the test specimen. These requirements all show the difficulties that will be found by inexperienced manufacturers who would endeavor to make small caliber rifles for our own or for foreign governments.

For this article an effort has been made to give the present status of the small arms question. There can be but little doubt, however, that in the near future some form of automatic or semi-automatic rifle to be fired by the individual will be adopted. It is also certain that a more extended use of the machine gun by the infantry in every service will be found upon all battle lines.

## Simple Sodium Lamp for Polariscope

SPECIAL lamps to produce a sodium flame for polariscopes are all expensive and more or less troublesome to adjust and maintain in working order. A simple, cheap and satisfactory substitute is here suggested.

It consists of a piece of fire-and acid-proof asbestos board about 4 inches square and $\frac{1}{8}$-inch thick, with a slit 3 by $\frac{1}{4}$-inch and 1 inch from the edge cut in the asbestos. This is used in connection with an ordinary Bunsen burner with wing-top. The asbestos board is supported about $\frac{1}{4}$ inch above the wing-top by means of a burette clamp, the burner being directly under the middle of the slit and parallel to it.

The flame burns around the edges of the slit, forming a broad double flame which is easy to locate with the instrument and of greater intensity than the usual flame. Salt is added around the edge of the slit as a saturated solution, by means of a pipette. The sides of the asbestos board may be bound with metal to support it at the ends of the slit. When one slit burns out another may be cut in the same piece of asbestos board, back of the first. The asbestos does not seem to affect the quality of the sodium flame.—*G. K. Foresman, Chemical Laboratory, Purdue University, Lafayette, Indiana, in The Journal of Industrial and Engineering Chemistry.*

# Concussion Blindness

## One of the Typical Developments of the War

By Arthur F. Hertz, M.D. and Arthur W. Ormond, F.R.B.S. Eng.

One of the principal ocular features of the present war is the number of cases of functional blindness due to the violent explosions caused by high explosive shells, bombs, hand-grenades, etc. These cases may or may not have sustained definite organic injuries, but the clinical symptoms characterizing their functional nature are very clearly marked. Usually the patient has been rendered unconscious by an explosion in his close vicinity, and on regaining consciousness he finds that he is unable to see. When examined he presents the following symptoms: The eyes are kept closed, the lids may be frequently "fluttered," or as one man stated, "he could not keep his eyes from twinkling." On attempting to open the lids the patient resists forcibly by means of his orbicularis; when this is overcome to a sufficient extent to see the globes, they are found to be rolled forcibly upward, and the pupils are always kept covered by the lids; he has great difficulty in looking downward, and complains of pain and photophobia, and shows marked fatigue as a result of the examination. In some cases I (A. W. O.) have noticed an acceleration of the pulse-rate and also perspiration. The photophobia is not, however, really influenced by light, as the condition does not diminish in very subdued illumination. These patients never move about as blind men would; they invariably avoid hurting themselves, but all the same they never relax, even if watched for weeks at a time, the groping action of people with extremely defective sight, and judged by every test they maintain this condition indefinitely and are undoubtedly psychically blind. The pupils react normally and the fundus shows no definite change. There is no difficulty in differentiating them from malingerers, as they pass through long periods of real mental distress and serious discomfort. These cases vary enormously in severity; some recover rapidly, others seem to go on indefinitely if not treated, or treated unsuccessfully. Any lack of recognition of the condition in the early stages enormously prejudices the prognosis. One patient having been told that he was blind remained so for several months, whereas probably if it had been recognized earlier that he was not blind and would recover he would have done so much more rapidly.

Early in the war I treated these cases in several ways, all with disappointing results; some of the slighter cases certainly did recover, but they recovered in spite of treatment and not on account of it. The main principles on which I worked were rest, tonics, deprivation or punishments, such as abstention from tobacco, confinement to bed or in isolation rooms, persuasion, encouragement, counter-irritation, talking, etc., but all these means were comparatively ineffective until suggestion and hypnosis were tried. In August, 1915, I thought it would be advisable to try suggestion, although I had a strong personal prejudice against its use, but when later on these cases still remained on my hands I consulted with Dr. Hertz, and we decided to start the hypnotic treatment. The method employed was to have the men singly in a darkened room, quiet, and resting in the most comfortable armchair the ward could provide. They were instructed as to what was to be attempted, and no demur was ever made by any of them, but, on the contrary, after the first experience they were always eager to continue the treatment. The patient had his eyes closed, of course, so that the assistance of light and fixation could not be obtained; but he was told to think of something pleasant and agreeable, not to take the slightest notice of the operator, to relax his mind by attempting to stop all incoming thoughts and to make his mind, as far as possible, a blank. We then used the usual methods of inducing hypnosis. In some cases—for example, Case 1—the hypnotic condition was obtained, but not in all, and I do not think it at all necessary to obtain complete unconsciousness; the main thing to be arrived at is to obtain a relaxation of the patient's mind and his muscles and to overcome his unconscious resistance.

The treatment is carried on thus for a few minutes, and having obtained the sleepiness or light hypnosis necessary, the patient is subjected to a forcible suggestion from the operator, who reiterates the patient's ability to see and to open his eyes, and to assert very vehemently that he is not blind as he imagines, but that his eyes are perfectly sound and that he *can* see.

The results have varied considerably as to rapidity of recovery, but all have shown marked improvement, the most drastic being that of the patient in Case 1, the most resistant being the deaf and blind man (Case 5). Cases of this nature have been constantly arriving from France and Gallipoli, but I here insert the notes sent to me by Dr. Hertz immediately previous to his departure for Alexandria, as they were the earliest ones with which we dealt and are quite typical, and in all of them, except in the last case, Dr. Hertz collaborated with me in their treatment; they, however, only represent a small proportion of the total number of cases.

NOTES OF CASES BY DR. HERTZ.

"*Case 1.*—The patient, aged twenty-two, was looking over a parapet on July 18th, 1915, when a shell struck the sandbags in front of him. He remembers the sand being thrown up into his eyes and his falling back so that he knocked his head. He remained unconscious for twenty-four hours. When he regained consciousness he found that he was completely blind, except that he could just distinguish light from darkness with his left eye. His eyes felt very sore and his eyelids were constantly moving up and down; he was partially deaf and had a severe headache. His hearing soon returned, and the headache rapidly improved, but the condition of his eyes had not altered when I first saw him with Mr. Ormond on September 17th. He was quite blind and there was a constant flicker of his eyelids, which were kept almost closed. On forcibly opening his eyes they were found to be turned so far upward that it was difficult to see even the iris. A few fragments of sand were still embedded in the conjunctiva but not in the cornea; there was no inflammation present.

"The patient was easily hypnotized, and while asleep he was told that he would be able to see when he woke up. The moment he awoke the suggestion was repeated very forcibly, and his eyes were held open. He cried out that he could see, tears ran down his cheeks, and he fell on his knees in gratitude, as he thought that he was permanently blind, and believed that his sight had been restored by a miracle. When seen again on Spetember 20th the external appearance of his eyes was normal, and he said that he was able to see as well as he had ever done. Mr. Ormond, however, found that there was some opacity of the vitreous of the left eye, secondary to hemorrhage from a retinal vessel, which had ploughed its way forward; this was doubtless a result of injury at the time of the explosion. There has been no return of symptoms, and the patient was well in every way when I last saw him on September 30th. His vision was 6/6 in the right eye and 6/36 in the left.

"*Case 2.*—The patient had an attack of blindness resulting from conjunctivitis caused by a sandstorm when in Egypt early in 1915. He recovered from this after ten weeks, and six weeks later went to the Dardanelles. On July 12th a shell struck a sandbag immediately in front of him and the sand flew into his eyes. He did not lose consciousness, but his sight gradually became more and more deficient until at the end of ten days he was only just able to distinguish light from darkness. Very slight improvement occurred spontaneously, but his condition when seen on September 17th was identical with that of the patient in the preceding case, a few pieces of grit being still embedded in the conjunctiva, although there was no inflammation.

"The patient was easily hypnotized, but there was very little improvement at the moment. Considerable improvement, however, occurred during the next three days. He was hypnotized on three more occasions; he could see perfectly well on September 30th, but still had some photophobia and wore dark glasses, as he could not avoid constantly blinking when they were removed. He was therefore hypnotized yet again, and it was suggested to him that the photophobia and blinking would now cease. The result was completely successful, as all symptoms had disappeared by October 4th, although no attempt had been made to remove the grit from the conjunctiva.

"*Case 3.*—The patient, aged twenty, was rendered unconscious for a few minutes as a result of the explosion of a shell near him on August 21st in the Dardanelles. Some of the powder was blown into his eyes, which were very sore when he regained consciousness, although he was still able to see quite well. During the next twenty-four hours his vision became more and more impaired. The powder was removed from his eyes when he was taken on board the hospital ship, and his eyes were bandaged. After a few days he thought he would be able to see quite well if the bandages were removed, but the medical officer in charge told him that it would be dangerous to do so. During the voyage home he was not allowed to remove the bandages, and he became more and more convinced that this must be because the medical officer thought he was blind. The bandages had not been removed when he was admitted into the hospital on September 25th. When they were removed he was found to be in exactly the same condition as the preceding patients. He could distinguish light from darkness, but was unable to see anything, and he kept his eyes turned up and his eyelids closed and constantly contracting.

"On September 27th he was hypnotized by Mr. Ormond, after which he found that he could see quite well, but the light still worried him and the blinking continued, though to a diminished extent. He completely recovered subsequently and returned to his depot.

"*Case 4.*—The patient, aged twenty-nine, was knocked over by a high explosive shell in the Dardanelles and remained unconscious for a considerable time. On coming round he found he could only distinguish light from darkness; there was no smarting of the eyes, but he constantly blinked. He had a slight headache, but was otherwise well. He began to improve about September 10th, so that he could recognize shadows passing in front of his eyes, but no further improvement occurred until he was hypnotized on September 18th. There was very slight improvement as the result of suggestion at the time, but when seen again on the 20th he said that he was beginning to recognize objects, and the blinking was less marked than before, but he still kept his eyeballs turned upward and his eyes almost closed. He was hypnotized again on September 20th and 25th, and when seen on the 30th his sight was quite normal and the blinking had completely ceased. Subsequent retinoscopic examination revealed the presence of a considerable degree of myopic astigmatism in the right eye and mixed astigmatism in the left.

"*Case 5.*—The patient was signaling from a gun limber on April 28th when he was blown up and remained unconscious for six days. There was no external wound, but on regaining consciousness he found that he was blind, except that he could just distinguish light from darkness; he was also completely deaf and was unable to speak. He regained his speech in June, after a fortnight's treatment by hypnotism at Plymouth, but his sight and hearing remained unaltered.

"When I saw the patient on September 17th he could only be made to hear by shouting down an ear-trumpet; he kept his eyelids almost closed and constantly twitching with his eyeballs turned upward. He was extremely depressed, as he had been told by an aurist that he would never regain his hearing, as it was said that nerve deafness of such long duration could not improve, although the drums were intact. He concluded that the blindness would also be permanent. It was not easy to hypnotize him as he was unable to see, and all suggestions had to be shouted down his trumpet, but Mr. Ormond succeeded in doing this at the first attempt. When seen on September 20th he said that his sight was distinctly better, and he was able with difficulty to open his eyes. He was much more cheerful, particularly when we told him that his hearing would also return, as his auditory nerves were no more organically diseased than his optic nerves. On September 30th there was some further improvement, as he could see everything in the outer part of his left field of vision fairly well. He was having a good deal of domestic worry, which no doubt prevented a more rapid improvement.

"*Case 6.*—The patient was unconscious for an hour after being blown up by a shell on August 7th. He was unable even to distinguish light from darkness when he recovered consciousness, but he very gradually improved. He was admitted into the hospital on August 22nd, after which improvement was much more rapid, and by the middle of September he had quite recovered without any special treatment.

"*Case 7.*—The patient, aged twenty, had never used his left eye, owing to an extreme degree of hypermetropia and amblyopia. When the other eye was covered he could only see very indistinctly with it, but in spite of this he managed to pass the medical examination when he entered the army. He was hit on the left side of the head by the butt of a rifle in June and was unconscious for a few minutes. When he regained consciousness he at once noticed that he could not see at all with his left eye, although he had hitherto been in the habit of neglecting the blurred image he saw with this eye. On August 10th he received a slight wound to his left thigh, but continued on duty. The wound had not completely healed, and was still somewhat painful when, on August 23rd, he was blown up by a high explosive shell. When he regained consciousness he was being carried on a stretcher. The pain from his old wound drew his attention to his left leg, and he thought that he was unable to walk. When taken on the ship he found that this was the case, although there was no new injury of the leg. He also complained of severe pain above the left eye, which he

kept covered by a shade, as he found that the least light greatly increased the headache; when the shade was removed he was unable to open the eye at all. For some time he was in an extremely excited condition, and he slept very badly owing to nightmares. His eye was kept covered by a shade during his journey home from the Dardanelles. On his arrival in England Mr. C. M. Ryley found that beyond the hypermetropia his left eye was normal, although he was quite unable to see anything with it.

"The patient was hypnotized on four different occasions. After the first he already slept better, the nightmares ceasing and the headache being less severe. On the second occasion, while still asleep, the shade was removed from his eye and he did not discover until half an hour after he woke up that it was no longer present, although up to that time he said that the least light caused extreme discomfort and spasm of the eyelid. After the third treatment he found that he could see almost as well with his left eye as before he was hit on the head. Meanwhile, he was still unable to walk without crutches, although the wound in the leg had completely healed, and there was no physical cause to account for this. When he was hypnotized for the fourth time it was therefore suggested to him that he would be able to walk quite well, and he subsequently recovered entirely."

These cases are typical of many others that have been treated similarly; in fact, fresh cases of this same condition are arriving every week and the "suggestion" treatment has not failed to give marked improvement in every instance. Up to the present we have had no failures, although the patient in Case 5 has proved the most resistant, but his deafness and domestic trouble, together with the very unfortunate handling of the case in the early stages, have no doubt been responsible for this. Mr. Francis Brook very kindly undertook the later stages of his treatment for me (A. W. O.) as owing to his greater experience in this work I thought he might obtain better results than I had effected. In November the patient was given an anæsthetic, and suggestion was tried during the stage of semi-consciousness, with marked success, as on the following day he opened his eyes voluntarily and has kept them open ever since. His speech and his sight having now returned, we hope that his hearing will not be long delayed.

Dr. Hertz and I trust that by publishing these cases greater attention may be drawn to these conditions, so that even if treatment cannot be applied at once the cases may not be prejudiced unfavorably by injudicious handling.

It is probable that the presence of sand, grit, etc., in the conjunctival sacs of some of these patients may have been the cause of the "suggestion" of blindness, but it was not present in all cases, and recovery took place without its being removed; as a matter of fact, they were, when present, all embedded in the conjunctiva and did not produce any irritative symptoms at the time the patients were under treatment.—*The Lancet.*

## Uses of Tungsten

The great use of tungsten is as an alloy of high-speed steel—that is, steel used for making tools used in metal-turning lathes running at high speed—to which tungsten imparts the property of holding its temper at higher temperatures than will carbon steels. In such steels from 16 to 20 per cent of tungsten is used. Saw blades are made which contain 1 to 2 per cent tungsten. The use of tungsten in magnet steels has consumed large quantities, but this use seems to be declining somewhat. The now well-known ductile tungsten is used for incandescent lamps, which are fast displacing carbon lamps. Lately greatly improved lamps, in which the wire is wound in helices and in which the globes are filled with nitrogen, have brought the consumption of electricity down to 0.4—0.5 watt per candle and have produced a close approach to white light. These lamps are furnished in candle powers up to 2,000. Undoubtedly the bulk of the research in the manufacture and use of ductile metallic tungsten has been carried out by the highly efficient corps of scientists under the direction of Dr. W. R. Whitney in the General Electric Company's wonderful research laboratories. Dr. C. G. Fink, of the company's staff, gives the probable or possible uses of worked tungsten as follows:[1]

The ductile metal is practically insoluble in all of the common acids; its melting point is higher than that of any other metal; its tensile strength exceeds that of iron and nickel; it is paramagnetic; it can be drawn to smaller sizes than any other metal; and its specific gravity is 70 per cent higher than that of lead. It was natural that a metal with such striking properties as these should soon find application other than that for incandescent lamps.

Wrought tungsten has been substituted with success for platinum and platinum-iridium as contact points in spark coils, voltage regulators, telegraph relays, etc. The service far exceeds that for platinum and platinum-iridium contacts due to the greater hardness, higher heat conductivity, and lower vapor pressure of tungsten as compared with platinum.

Electric laboratory furnaces with tungsten resisters are of two types. In one a tungsten wire is wound on an aluminium tube in an air-tight box with a hydrogen atmosphere. In the second a tungsten metal tube takes the place of the helical carbon resister in an Arsem vacuum furnace.

Tungsten gauze is used successfully for separating solids from acid liquids in the laboratory. This gauze could well be used on a commercial scale; for example, for the removal of sludge from copper refining baths, and for centrifugal apparatus in general whenever acid liquids or acid gases are dealt with. Furthermore, it might be used in apparatus such as described by Cottrell for the removal of sulphuric mist from gases.

Wrought tungsten targets for Roentgen tubes have proved to be one of the most interesting applications.

For thermocouples the tungsten-molybdenum couple is not less interesting. The electromotive force increases with the temperature up to about 540 deg. Cent. (12½ millivolts), then decreases and passes through 0 millivolts at about 1,300 deg. Cent. This couple is very convenient for high-temperature measurements in the tungsten-hydrogen furnace.

For standard weights tungsten is also well suited, since wrought tungsten can be made so hard that it will readily scratch glass and still be ductile; furthermore, the density is high (19.3 to 21.4) and it is unaffected by the atmosphere. Tungsten weights remain wonderfully constant.

Besides the applications of tungsten cited above, many others have been but partly worked out and others merely suggested. Owing to its chemical stability the finest sizes of wire down to 0.0002 inch or 0.0005 millimeter in diameter are well adapted for galvanometer suspensions and for cross hairs in telescopes. It has also been suggested to use these fine wires in surgical operations in place of the coarser gold and silver wires. A further suggestion is the use of the wire in musical instruments.

Acid-proof dishes and tubes have been made out of tungsten; furthermore, tungsten wire recommends itself as a unit resistance, since it can be made absolutely pure, can be easily duplicated, and is not corroded.

Since tungsten is paramagnetic and elastic, it is being tried out in electrical meters, replacing the phosphor-bronze springs. Similarly watch springs could be made which would never become magnetized. Finally, tungsten pen points, tungsten drawing dies, tungsten knife blades, tungsten reinforced asbestos curtains and fireproof coverings, etc., were mentioned.

TABLE OF PHYSICAL AND CHEMICAL PROPERTIES OF DUCTILE TUNGSTEN.

Density, 19.3 to 20.2.

Tensile strength, 322 to 427 kilograms per square millimeter.

Young's modulus of elasticity, 42,200 kilograms per square millimeter (steel 20,000).

Melting point, 3,177 deg. Cent. (Langmuir); 3,100 deg. $\pm$ 60 deg. Cent. (Pirani & Meyer).

Boiling point, 3,700 deg. Cent.?

Thermal conductivity 0.35 gram. cal. per centimeter per second per 1 degree (Pt. 0.166).

Expansion coefficient $4.3 \times 10^{-6}$ (Pt. $8.8 \times 10^{-6}$.)

Specific heat 0.0358 (Weiss).

Resistivity, hard: 6.2 microhms per cubic centimeter; and annealed 5.0 microhms per cubic centimeter.

Temperature coefficient of resistance, 0.0051 (0 degree—170 degrees).

Magnetic susceptibility: $+0.33 \times 10^{-6}$ (Honda); that is, practically nonmagnetic.

Hardness 4.5 to 8.0 (Mohs scale).

Insoluble in HCl, $H_2SO_4$, $HNO_3$, HF, NaOH, KOH (aq), and mixtures of $K_2Cr_2O_7 + H_2SO_4$, soluble in mixtures of HF and $HNO_3$ and in fused nitrates and peroxides.

The boiling point of the metal has not yet been determined.—*Mineral Resources of the U. S., 1913—Part II—U. S. Geological Survey.*

[1] *Metall. and Chem. Eng.*, vol. 10, pp. 580–581, 1912. A paper delivered before the section of electro-chemistry, Eighth International Congress, Applied Chemistry, Sept. 6, 1913.

## Sub-Aqueous Storage of Oil Fuel

A recent issue of the *Engineer* contains a description of a method of storing oil fuel for submarines under water, both to provide a secret and convenient fuel station, and to protect the supplies from guns and aircraft, and it may be inferred from the text that such stations have been established, and are in operation by the British government. One of the barges mentioned is in the form of a tank 150 feet long and 30 feet diameter, with hemispherical ends, which would carry 2,400 tons of liquid fuel, and could be submerged by admitting water to the compartments at the ends. To bring the vessel to the surface compressed air was introduced to force out about 30 tons of ballast water, or either oil or water could be pumped out through flexible tubes to make the vessel rise.

Another arrangement described is a storage barge, which would not be wholly submerged. This would be a cylinder 450 feet long by 50 feet 9 inches mean diameter, and capable of containing 20,000 tons of fuel. An inclosed passage running the entire length of the vessel would accommodate the valves and operating mechanism, and would also furnish reserve buoyancy.

It was also suggested that vessels and barges of similar construction might be used for transporting fuel oil across the Atlantic by towing.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